THE TECH ENGINEERING NEWS

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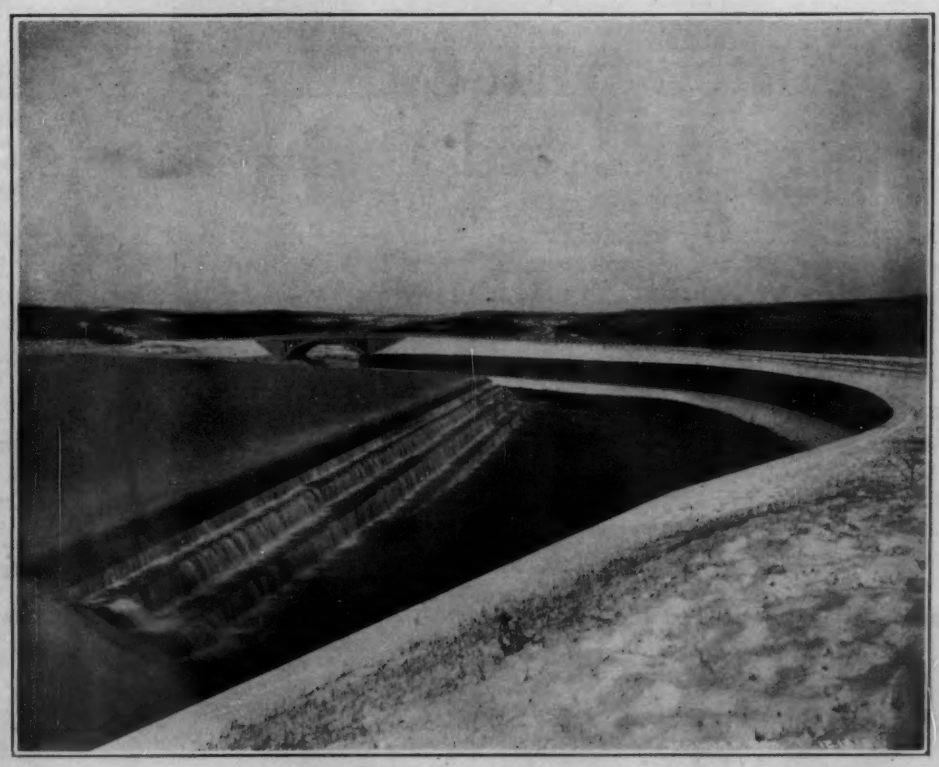
VOL. VI, No. 5 DECEMBER, 1925



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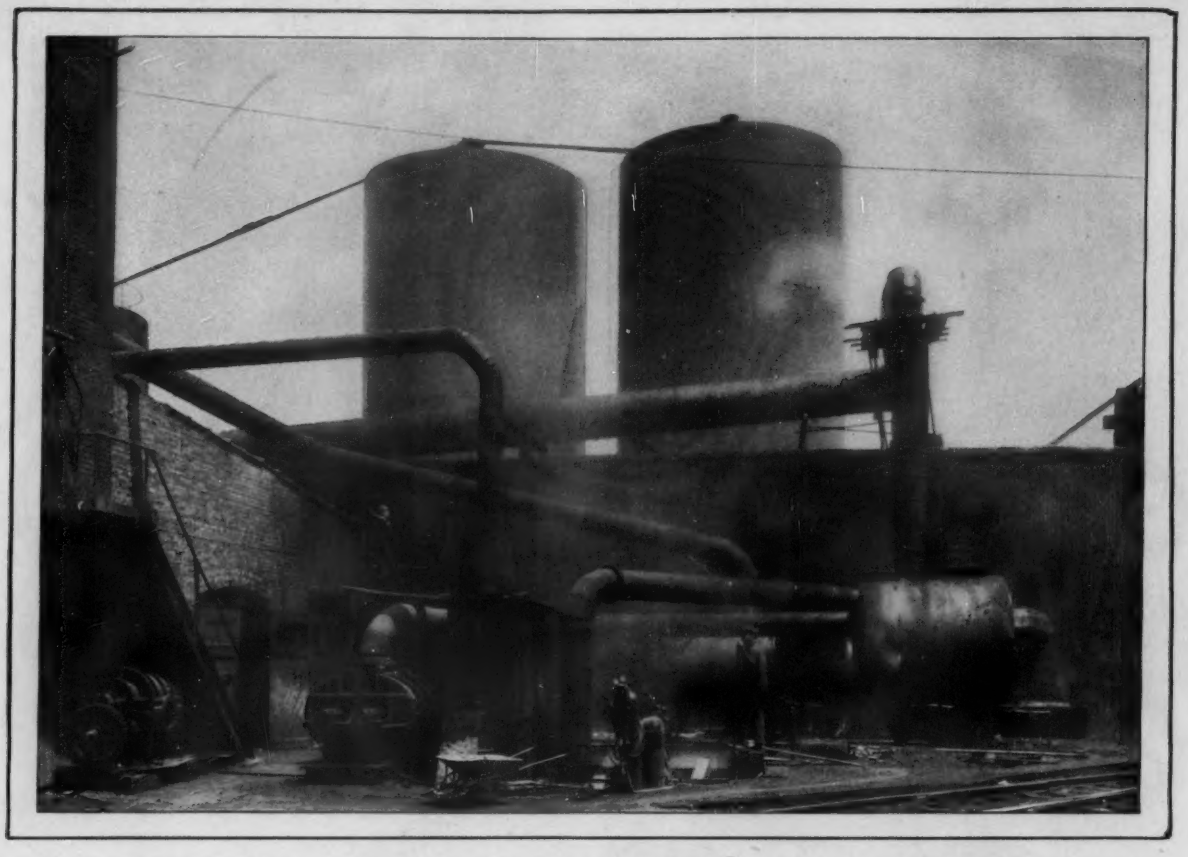

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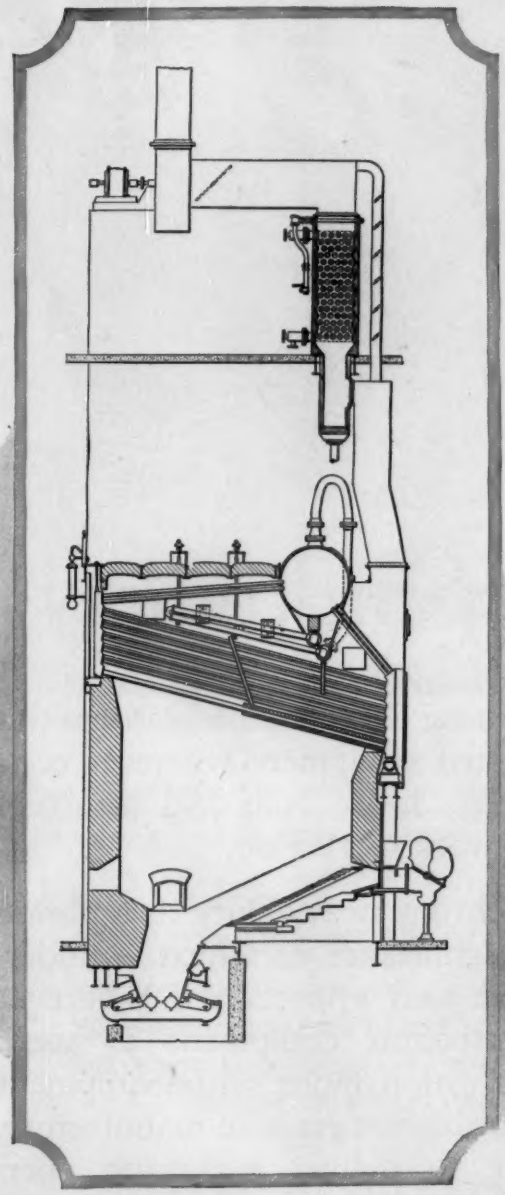

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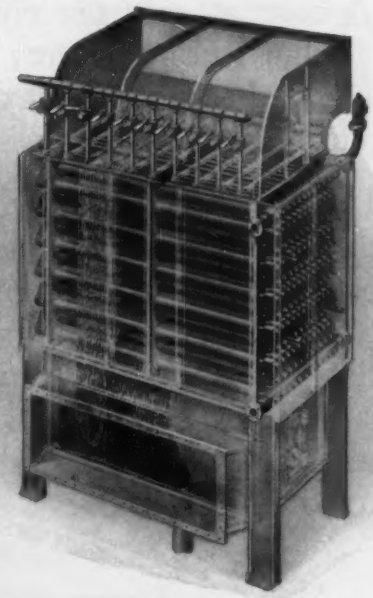

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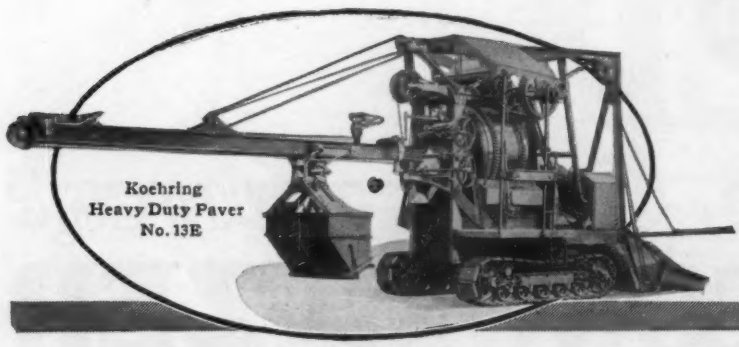
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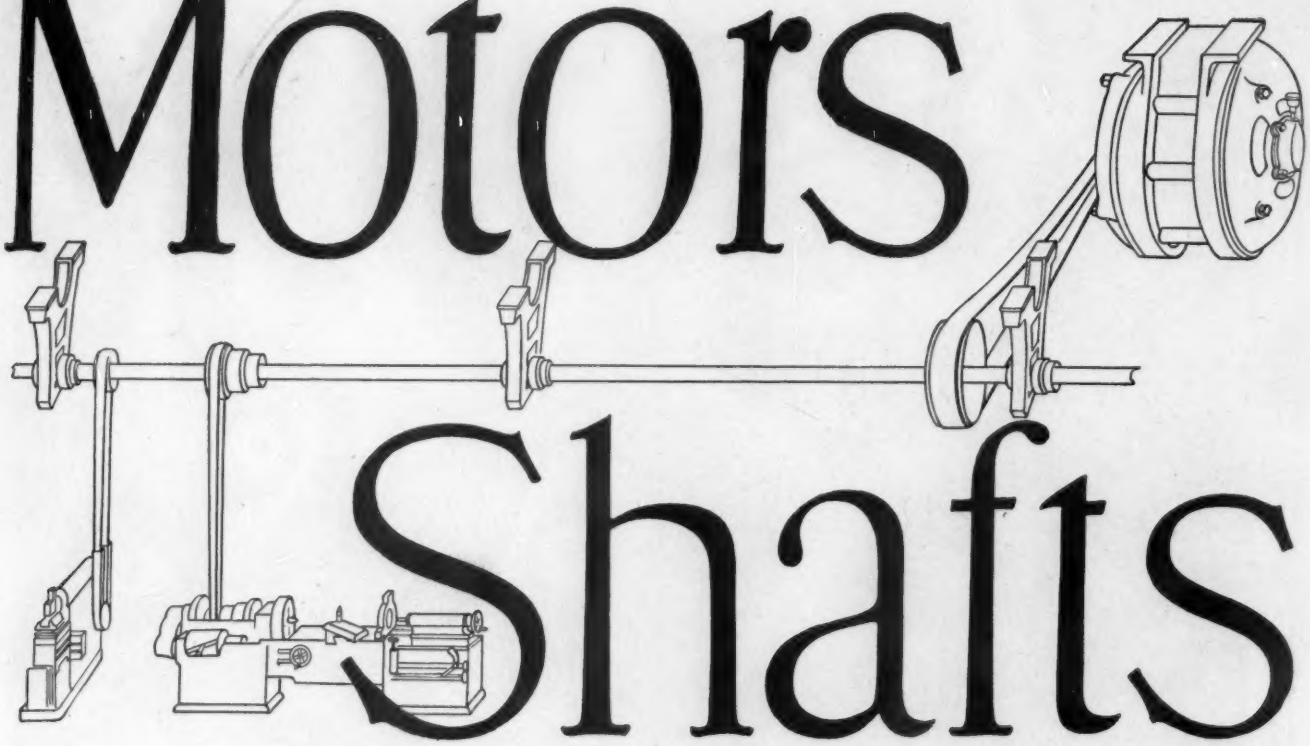

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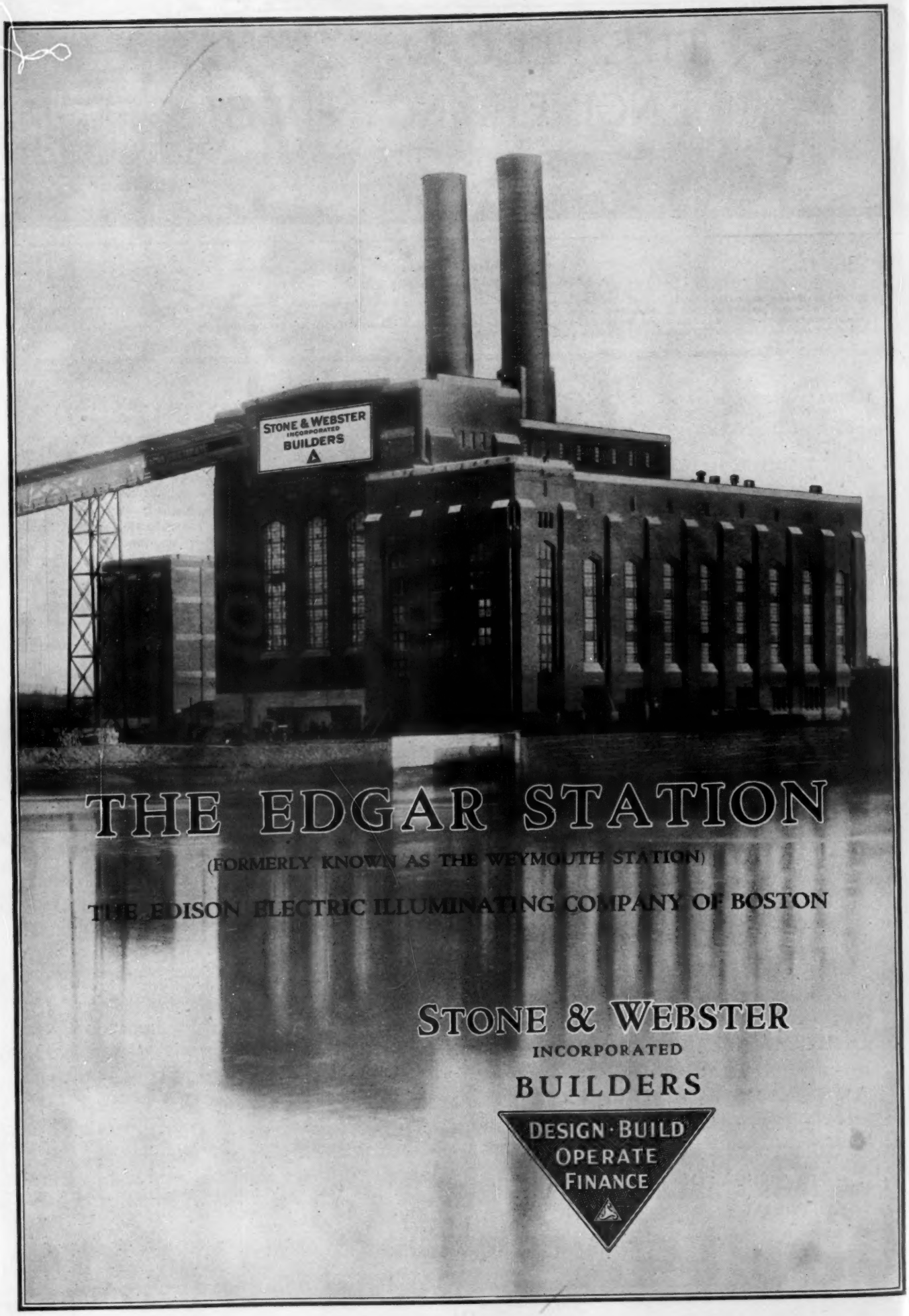
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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME VI — DECEMBER, 1925 — NUMBER 5

The Technical Graduate in the Public Utility Field

An interesting account of the opportunities in this line of activity for the engineering college graduate, including a description of the Doherty Training-School

By B. E. GROENEWOLD, '25

Junior Engineer, The Cities Service Company, Denver, Colo.

THE undergraduate engineer, when thinking of his future, far too often gives but a superficial examination to the possibilities of many fields. Frequently, with the fruits of his four years of labor in plain sight ready for the June picking, he is fired by great ambition to get out and get into productive labor immediately. He has spent sixteen years in study as preparation for his entrance into the great business and industrial world, and feels entitled to an immediate opportunity to show what he can do. In all justice it must be said that fully ninety per cent of the seniors realize that no enormous salaries are theirs at once, and that some practical experience is necessary before these can be obtained, but a great majority of the men desire an immediate chance to put their assimilated knowledge to work in positions where there are opportunities for comparatively rapid advancement in the next few years. This attitude causes many of them to become prejudiced against many of the greatest fields of opportunity, and they give but scant attention to the offers from concerns in those fields.

Among that classification falls the Public Utility field. Few students ever realize the gigantic scope of this line of activity, for they have come to take the products and their distribution as matter of fact and commonplace. Just as very few men could tell how many steps there are leading up to their doors, so there are very few students who have any idea of the size of public utility investments or the enormity of their scope. In this country there is over four times as much capital invested in public utilities as in the steel business, over eight times as much as in the automobile business, and over ten times as much as in the meat-packing industry. In addition, it is one of the most rapidly expanding fields of industry in the country, for new uses are constantly being found for electricity, for gas, and for the other products. The industry is being sorely taxed to keep up with the increased demand. There is a wonderful future for engineers in this field, not solely as strict engineers, but as future executives.

This article is the first of a series to discuss the future of the technical graduate in the various professional fields, and the training-schools in those fields. It is hoped that this series will be of assistance to the men of the senior class who are to be confronted with the problem of deciding just what field of activity they will enter upon graduating.

The second article of the series, to appear in the January issue, is "The Bell System and Its Trained Personnel," by O. W. Eshbach and J. O. Perrine.

But the rub comes to the student looking over the field in the fact that he must spend several years after his graduation in getting practical experience at comparatively low rates of pay before he can begin his intended upward climb to fame in earnest. He looks into the future, but not far enough, for the immediate future looks too dark for his great ambitions. He does not examine far enough to realize that the officials of the big companies in this field have taken all factors into consideration and recognized that the best method of obtaining men suited to fill the opportunities that arise is that of training college graduates in all phases of the business, and then finding the right position for the right man.

The result of this has been the establishment of training-schools, where men are given the opportunity to obtain a working knowledge of the whole business and find out just where they are best fitted and most likely to make the future a success. These schools supply men trained in the various ramifications of the industry to fill the many opportunities that are constantly arising in this ever-expanding field. However, few students realize the great opportunity that is open to them through these training-schools, and here the companies themselves are somewhat at fault, for, outside of the men studying electrical engineering, the percentage of students who know anything at all concerning these schools is exceedingly small, and in most of them there are opportunities for men in all branches of engineering. In order to give some idea of what these schools are like, this article will endeavor to describe the workings of one of them, the Doherty Training-School, operated by the Cities Service Company at one of their subsidiary properties — the Public Service Company of Colorado, located at Denver.

Here it is endeavored to equip the men selected for the course not only with practical experience in the various phases, but to train them to become executives. It is necessary to give them that broad view which must be theirs if they are to make a real success of their work. The ideal executive must be able to help protect invest-

(*Continued on page 212*)

The Development of the Air-Cooled Aviation Engine

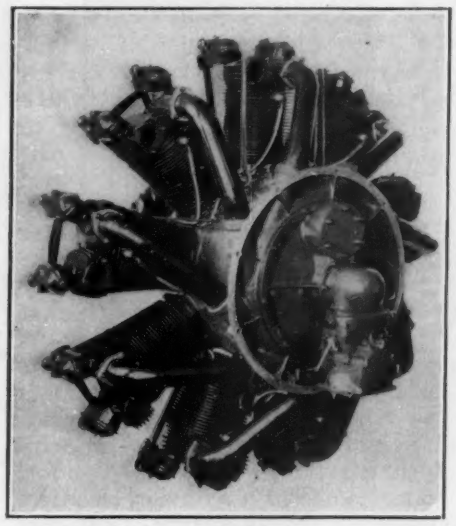
A discussion of the problems involved in heat conduction in air-cooled cylinder heads and their relation to engine dependability

By GEORGE J. MEAD, '16

Vice-President, The Pratt and Whitney Aircraft Co., Hartford, Conn.

THE single, most important improvement of recent years in aircraft engine dependability has been the satisfactory application of air cooling. A large per cent of the present power-plant failures are due to the "plumbing," of which the water-cooling system forms a large part. Originally, the lightness of the air-cooled type made it particularly desirable, but as little or no engineering experience was available, the first engines were unsuccessful. After nearly twenty years of effort air cooling has come into its own.

During the last five years the principal aim of the aircraft engineer has been to increase the dependability of the power-plant as a whole. First, the weaknesses of the water-cooled type were studied and overcome. Then it was found that, regardless of how dependable the engine was, the auxiliary systems were prone to give trouble. This encouraged intensive development of air-cooling in order to eliminate the water-cooling system. As a result, great progress has been made in this field, and the basic engines are not only as reliable as the water-cooled type, but owing to the elimination of part of the plumbing the over-all dependability has been tremendously increased. For commercial purposes, particularly, this is a most important development.

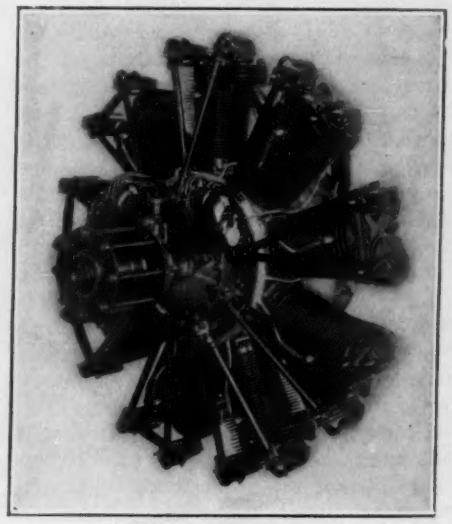


LARGEST AMERICAN RADIAL ENGINE (¾ REAR VIEW)

This engine is equipped with a built-in supercharger.

The principal difficulty with the original engines was improper cooling, which resulted in overheated cylinders, valves, and pistons. The power outputs were low, and the fuel consumptions high. These engines, as a matter of fact, were cooled by the excess fuel consumed as much as by air. Both L and I head cylinders were used. The material was cast iron. In an effort to provide more adequate cooling, the rotary type of engine was devised. It was thought that the rotary motion of the cylinders, in addition to their translation, would improve the cooling. These engines had fixed crankshafts about which the cylinders and crankcase rotated. The cylinders had I heads, and were made of steel to reduce the centrifugal loads imposed upon the crankcase.

It became obvious that the cylinder design itself must be improved before any real progress could be made. To this end a great deal of work was done during the war. The iron and steel cylinders used hitherto had particularly thin walls for lightness. This was poor design for rapid and uniform heat transfer, and caused local hot spots. The introduction of aluminum for the cylinder heads overcame this trouble. It could be used in thick sections without excessive weight, and due to its high heat conductivity it was possible to secure proper heat distribution and fairly uniform cylinder head temperatures. The first attempt to use aluminum took the form of a poultice head such as used in the British Cosmos, Bristol, and ABC engines. In these engines the cylinder, including the top of the combustion chamber, was of steel, while the auxiliary or poultice head carried the valve ports and guides. In this type it was found particularly difficult to maintain the proper contact between the steel and aluminum for good heat transfer. A further study of the problem led to eliminating the steel head by casting the aluminum directly onto open-ended cylinder barrels. This method involved foundry difficulties, and a reliable joint could not be secured. A further development resulted in threading the head and sleeve, which were put together with the head hot so that an initial shrink was obtained. This type of cylinder was developed by the Royal Aircraft Factory and is used in the Armstrong-Siddley engine. There are various modifications of these designs, for example, a complete aluminum cylinder, including cooling fins and holding-down flange, in which case the piston travel is on a plain steel sleeve shrunk into position in the aluminum barrel. Another modification uses a steel sleeve with integral holding-down flange which is threaded into the aluminum head. The head, in this case, is extended in such a manner as to carry all the cooling fins. Except for the built-up construction and cooling fins, the present air-cooled cylinder design is very similar to that which is used in modern practice in efficient water-cooled cylinders.



LARGEST AMERICAN RADIAL ENGINE (¾ FRONT VIEW)

Showing aluminum cylinders and enclosed valve gear. The cylinders are 6″ x 6½″.

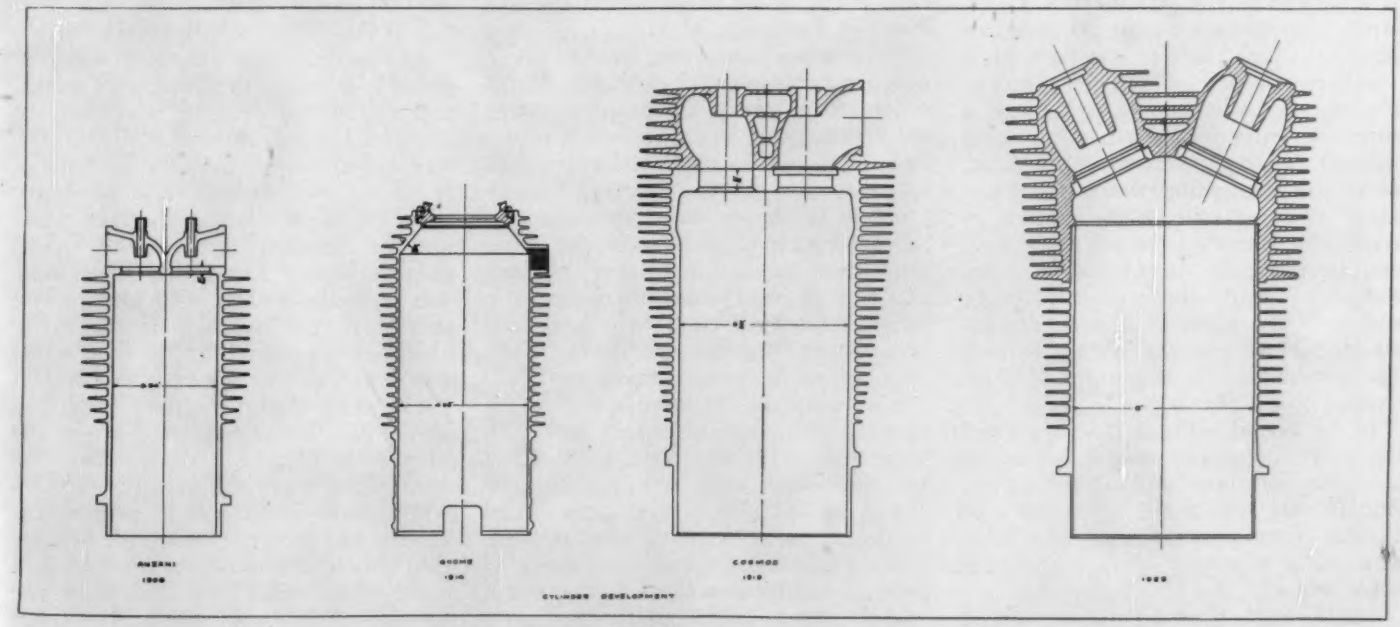
Each associated part of the cylinder, such as the valves, spark-plugs, and pistons, has come in for the same kind of a thermal study. In each case local heating has been prevented by the provision for rapid heat transfer to the cooling medium. In the case of the valves, a heavy ring around the circumference of the head transfers the heat, due to leakage, over the entire seat. This prevents warpage and overheating. The tulip shape has been adopted because a certain amount of

elasticity is provided between the stem and the head which allows for proper seating. This type runs cooler than a mushroom valve, probably due to the retention of a certain amount of burnt gas in the tulip. A large variety of different materials has been used at one time or another for valves. Principal among these, however, are iron, carbon steel, tungsten, chromium, and silchrome. These materials have been used in the order mentioned, and to date silchrome has been found to be the most satisfactory. The valve seats have come in for considerable attention, also. Neither iron nor steel has been found satisfactory, as the continual pounding of the valve on the seat results in excessive wear, so that the tappet clearance is rapidly decreased until the valve rides off its seat on the back of the cam. As a result of a great deal of experimentation, aluminum bronze is now used for valve seats. This material is shrunk into the aluminum cylinder heads, and as it has practically the same conductivity as the aluminum, no difficulty is experienced with the seats becoming loose. Since a certain amount of heat is dissipated through the exhaust valve stems, it has been found good practice to make these of comparatively large diameter, and provide valve guides completely surrounded by an aluminum boss. For purposes of lightness in the past, the valve guides have often extended unprotected directly into the exhaust flame, so that they absorbed a large amount of heat and thus became poor transfer agents. As an indication of the durability of the present valves and seats, the record of the Wright E-4 engine is of interest. This engine ran 315 hours at 1800 r.p.m., developing a mean effective pressure of 122 pounds. During this period the valves received no attention. At the conclusion of the test, the power was as good as at the beginning, which indicates that the valve conditions had not changed appreciably. The performance of this engine, although it was of the water-cooled type, can be duplicated at present with the air-cooled engine. The modern piston is made of aluminum with an extremely thick head with tapering side walls, so that the heat flow to the cooling medium through the piston rings is unrestricted. The piston material has passed through the same cycle as the cylinders, namely, iron, steel, and aluminum. The proper provision for adequate heat dissipation has resulted in perfectly satisfactory spark-plugs. In the case of most air-cooled engines the plugs are carried in dural or aluminum bronze bushings shrunk into position in the aluminum cylinder heads.

With the development of satisfactory cylinders came the necessary study of their proper arrangement for maximum cooling. Originally, two-cylinder opposed engines were built, such as the Anzani used by Bleriot to cross the British Channel in 1909. As more power was required, the radial form of engine was devised, first with three cylinders and then with more, as the power required increased. The radial form provides uniform cooling for each cylinder when a single row is used. Considerable engineering work has been carried on with double row radials, "in line" and "Vee" types of engines. Years ago the Vee type was brought out by the Renault Company in France, and more recently by the Royal Aircraft Factory. These R.A.F. engines were used to a certain extent during the war. Apparently the modern cylinder can be used in any combination so that there is no particular limit to the total power output with air cooling. For powers up to 450 h.p. the radial form gives the simplest engine, while the Vee engines are entirely practicable for larger powers.

The radial arrangement of cylinders brought up a number of new mechanical problems. To begin with, the entire power of the engine is applied to a single crank pin. The method of doing this is by the use of a so-called "master" rod, the big end of which bears directly upon the crank pin. The big end is provided with bosses for the attachment of the "link" rods, and in this manner the power of the other cylinders is applied through the master rod to the crank. New lubrication problems were also encountered, principally in connection with the inverted cylinders. Oil is prevented from reaching them by means of scraper rings located at the bottom of each piston. In addition to this, the cylinder barrels extend into the crankcase in such a manner as to prevent oil running into them. An oil sump is arranged beneath the crankcase of sufficient capacity to hold all the oil which drains

(*Continued on page 206*)



CYLINDER DEVELOPMENT

From left to right: Anzani (1908), Gnome (1914), Cosmos (1919). Latest development (1925).

The Water Supply of the City of New York

An account of the early history of the city's water supply — Existing and possible new sources of supply discussed

By J. Waldo Smith, '97
Consulting Engineer, Board of Water Supply, City of New York

NO article dealing with the water supply of the City of New York would be complete unless it contained a brief account of its early history, as nearly as it can be obtained.

The lower end of Manhattan Island was settled about the year 1610. Presumably, the settlers were supplied with spring and well water, and the town continued to grow until it had reached a population of 1000 in 1658, when the first public well was established. Later on, more public wells were dug and the community extended, but no effort was made to establish a public water supply until 1774, when the city, then having a population of 22,000, made a contract to take water from what was known as Collect Pond, in the neighborhood of what is now Franklin Street. To cover the cost of this work, the city issued water bonds. Just before the construction was finished, the Revolutionary War was on and the work was abandoned. During this period there was active and continuous agitation regarding the adequacy of the supply of water and its quality. As the city expanded, the wells became contaminated and produced serious epidemics, and the death-rate increased rapidly. The first mention of other than well supplies came in 1798, when the Bronx River as the source of supply was urged.

By 1799 the population was 60,000, and legislation was sought and secured to incorporate the Manhattan Company, later known as the Manhattan Bank, to which the city was permitted to subscribe a part of the capital stock. The purpose alleged was to furnish a supply of water for the city — the real purpose was to get a charter for a bank. So in the succeeding years this company was not particularly active in materially bettering the water supply, and in the next twenty-three years laid only twenty-three miles of pipe, and was the subject of severe complaint for almost the entire period. The population in this time had increased to 155,000.

In the period between 1816 and 1835 there was one continuous series of agitation for more and better water. But it was not until 1832 that the Croton River was definitely put forth as a source of supply. The population then was 220,000.

In 1834 the Legislature authorized the city to begin the necessary works to bring Croton water to the city. The work was begun at once, and after many delays the first water flowed into the city in 1842. The decision to go to the Croton River showed great foresight on the part of the officials of that time, as they reached out for a source which by successive development of reservoirs and the construction of a second aqueduct, in 1890, produced a dependable supply of 330,000,000 gallons daily, sufficient to supply the City of New York until 1917, and which will continue to be used for an indefinite period in the future.

The outstanding fact in all its history, which is, I think, without a parallel, is that for a period of 180 years, during which the city had grown from its beginnings to a population of 360,000, it had been entirely dependent on local sources of wells and ponds, augmented more or less by water secured by transportation in barrels and water carts from Long Island or other sources. The general conditions met with during this period are strikingly like what we find today. There are about the same bickerings now as at that time, when the water supply was much discussed and became one of the trying questions of the succeeding administrations of the city's affairs. Propositions and counter-propositions were made and discussed. All sorts of sources were recommended, even going so far afield as the Passaic River at Paterson, N. J.

Time after time the Bronx River was put forward as an economical and satisfactory source of supply. After the first Croton Aqueduct was authorized, each succeeding legislature had to deal with matters relating to the problem of the work. The owners of the land seemed of exactly the same disposition as they are today, in their efforts to get exorbitant prices from the public authorities for their land, and caused great trouble and delay in the progress of the construction work.

Following the introduction of water through the new aqueduct in 1890, there was made available to the city an additional aqueduct capacity of about 300,000,000 gallons daily. The total available supply was trebled. Even this addition was inadequate to meet the situation for a long period, and as early as 1897 the city's engineers were busy investigating new sources of supply.

This brief history carries us up to a period after the creation of Greater New York by uniting into one municipality, under the corporate name of "The City of New York," the various communities lying in and about New York harbor, including the city and county of New York, the city of Brooklyn and the county of Kings, the county of Richmond and part of the county of Queens. It was the first time that a comprehensive water supply could be undertaken for all portions of the greater city and interconnected so that the various sources of supply could be used as most desired.

New York has been unusually fortunate in being able to secure a supply of very wholesome water within a reasonable distance. It has developed within thirty miles of its boundary sufficient water to supply a population of nearly 5,000,000 people.

Before 1900, however, it became evident that a large addition would have to be supplied to keep pace with the rapidly growing population. After many investigations and reports by eminent engineers, and the securing of the necessary authorization of the municipal and state authorities, it was decided to go to the Catskill Mountains, about 100 miles distant, and construct a supply which would deliver not less than 500,000,000 gallons daily. The watersheds, as developed, will furnish a dependable supply of 600,000,000 gallons daily, and the aqueduct will carry a maximum of about 650,000,000 gallons daily.

The plan for this entire work, with a report and estimate attached, was prepared in a period of about nine weeks, and the whole project, involving an estimated expenditure of $177,000,000, was approved by the city authorities in about two weeks. The necessary approval of the state authorities could not be secured until about seven months later. From this time work was pushed forward with energy and efficiency, and in spite of the many obstacles encountered the first water was delivered to the city in December, 1915. The commissioners, in giving an account of their stewardship to the Mayor in October, 1917, when the first increment of the supply, 300,000,000 gallons daily, was in general use throughout the city, were able to state that this result had been accomplished more than one year ahead of the estimated time and about $7,000,000 below the estimated cost.

Throughout the prosecution of the work the greatest care was exercised

to co-ordinate the contracts so that, in case of any exigency, the Catskill water might be delivered into the city through the Croton Aqueduct, although the construction work was far from completion. In point of fact, Catskill water could have been delivered into Croton Reservoir over four years earlier, if a drought like that of 1911 had occurred.

The main supply of the new system is drawn from the Ashokan Reservoir, located in the Catskill Mountains about sixteen miles west of Kingston. This reservoir has an available capacity of 128,000,000,000 gallons, or enough to cover the Island of Manhattan to a depth of thirty feet; and its contents could supply the whole of Greater New York, at the present rate of consumption, for about five months. It is twelve miles long and has a maximum depth of 190 feet. Before the water was impounded therein, seven villages were removed and eleven miles of the Ulster and Delaware Railroad were relocated. The problems involved in the removal and relocation of the railroad were complicated, but, after negotiations covering several years, were satisfactorily solved by the Board of Water Supply acting in co-operation with the Board of Estimate and Apportionment of the City of New York.

The construction of the aqueduct, which is 120 miles in length from the Ashokan Reservoir to the terminal reservoir on Staten Island, was divided into a number of parts, the most difficult being the tunnels under the Rondout Valley, the Wallkill Valley, and the Hudson River. The Hudson River, flowing between the mountains and New York City, with its deep rock gorges, had to be crossed. The engineers, rejecting themore obvious but less secure and more costly means of crossing by bridges or pipes, sank shafts about 1200 feet deep and drove a tunnel in the granite rock 1114 feet beneath the river, through which the water flows under pressure. These tunnels are 14 feet in diameter inside. The interior dimensions of the cut-and-cover aqueduct are 17 feet high by 17½ feet wide.

For the city's security, with so long an aqueduct, it was very important to have a large store of water near by. Branching valleys three miles north of White Plains afforded a site for Kensico Reservoir, which was formed by constructing one of the great masonry dams of the world, 1825 feet long, with a maximum height of 307 feet. The water held in reserve there could supply the city's present rate of draft for about a month. This Kensico Reservoir is the objective point of the Bronx Parkway, a beautiful highway from New York City.

The third important reservoir is that of Hill View, in Yonkers, at the New York City line, which is an equalizing reservoir for the varying consumption of New York City during the day and night.

In order to deliver this large quantity of water into the distribution system, it was decided, so as to avoid congestion and to leave adequate room for subways, conduits, and other important underground structures which necessarily should be near the surface, that, instead of overburdening the subsurface with more pipes and structures than already existed, delivery should be made through a large tunnel located deep in the solid rock which underlies Manhattan Island and other parts of the city, bringing the water to the surface about every three-quarter mile to make connection with the large distribution pipes. This tunnel is eighteen miles long, and at the time it was built was the longest tunnel in the world. Since then the Shandaken Tunnel, which turns a portion of the flow of Schoharie Creek from the north to the south, has been constructed, and it is about 0.1 mile longer than the tunnel under the city.

Great care was taken in making extensive underground investigations before the plans for construction were perfected. This required the making of 74,000 feet of wash borings and 166,000 feet of core borings.

The work was awarded under a very complete and comprehensive form of contract and detailed specifications, which included specific payment items for all work which could be reasonably segregated and classified, instead of having it included in the general expense, as is often done. The information given to bidders was very complete, so that they could intelligently fix prices at which they could do the work with profit. It is notable that all the contracts, of a total value of about $126,000,000, were completed by the original contractors or their legal representatives, without intervention by the city, at a cost approximately over three per cent less than the amounts bid. Provisions for safeguarding the health of the contractors' employees were included, as well as stipulations as to furnishing proper housing facilities, adequate water supply, good sanitation, and medical and surgical attendance.

New York City grows and grows. Investigations have been under way for several years looking to the development of new sources of supply and another large aqueduct to the city. If the states of New York, New Jersey, and Pennsylvania can agree as to the apportionment of the water of the Delaware River, which marks part of the boundary of the three states, the best source for an additional supply would be that portion of the watershed of the Delaware River lying within the State of New York, about 2400 square miles, from which it would be possible to take over 1,000,000,000 gallons of water daily. The distance of the principal storage reservoir would be only about sixty miles from the city. A compact defining the rights of each state has been prepared and has been approved by duly appointed representatives of the three states, but has not yet been ratified by the states of New Jersey and Pennsylvania. If water cannot be secured from this

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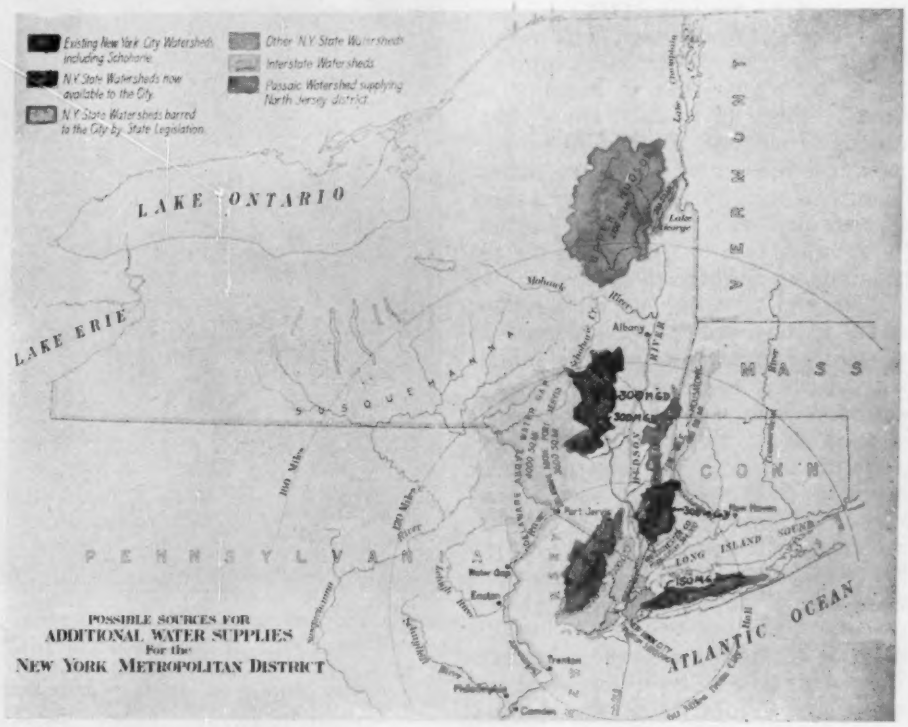


Sulphuric Acid—a Pillar of Modern Civilization

An account of the consumption of the acid, including a brief discussion of its history, properties, and manufacture

By WILLIAM M. RAND

Merrimac Chemical Company, Boston, Mass.

OVER seven millions of tons of Sulphuric Acid are consumed annually in the United States. To one unfamiliar with the acid, the natural questions arise, "What is done with it? Where is it used?" Before the public it seldom appears in its natural state. The shelves of drug stores, the college and school laboratory, the battery repair station, are the places where the public sees Sulphuric Acid. Unlike steel, rubber, and cotton it is not familiarly known as a raw material. Few manufactured articles have free Sulphuric Acid in them, yet it is difficult to find any manufactured article that is not connected either directly or indirectly with this acid. It is used most frequently as an intermediate, an agent, a means to an end, and not as a raw material. Fifty-two per cent of the total consumption of the acid is used for the manufacture of fertilizer. Phosphate Rock treated with it forms Acid Phosphate, so necessary to the farmer for maintaining the fertility of his land. Refining Petroleum, including oils, gasoline, naphthas, and paraffin, requires an additional twelve per cent. Tens of thousands of tons go into the steel and iron mills for pickling or cleaning the metal so that it may be worked. This industry takes eight per cent. The textile industry takes but three per cent of the consumption, but its uses for bleaching, for mercerizing cotton, and for burning out the vegetable fibers in wool are important.

Its miscellaneous uses, amounting to ten per cent of the consumption, are so numerous that to attempt to mention them all would form a voluminous catalogue. Some of these uses are in the refining of sugar, the manufacture of ceramics, the purification of coal gas, the tanning of leather, the manufacture of fungicides, the reclaiming of rubber, the manufacture of soap and of yeast, in photography, and—two very important uses—in metallurgy and explosives. In metallurgy, besides its employment in cleaning steel, iron, copper, and silver, it is used in the flotation of zinc, copper, and lead ores. That much-mooted question, "Who won the war?" may be settled by compromising on that modest, retiring applicant for the honor—Sulphuric Acid! Without it there could have been no high explosives. The nations producing the greatest amount of explosives held the balance of power. Sulphuric Acid is a necessity in the manufacture of dynamite, picric acid, T.N.T., and other high explosives. During the Great War the Government had plant capacity of a million tons of Sulphuric Acid, which, when added to the capacity of industrial plants, brought the total supply to the allies of the United States to ten million tons per annum. Many of our common comforts and luxuries, which we have come to look upon as necessities, would be impossible without Sulphuric Acid. Industrial progress would be turned back over a century and a half. It is summed up by a distinguished German, who said in effect that a nation's civilization is measured by its consumption of Sulphuric Acid.

Eighty-five per cent of the consumption has been accounted for. The important consumer, the chemical industries, requires the remaining fifteen per cent.

As Sulphuric Acid makes possible directly hundreds of manufactured articles, indirectly it assists in the manufacture of thousands. It is the keystone chemical. There is more of it used in all industries than any other chemical. Let it suffice to mention a few of the more important chemicals in the manufacture of which Sulphuric Acid plays an important part.

Through a process of treating Salt and Sulphuric Acid, Muriatic Acid is formed. This acid is used in the gelatine and glue industries, the sugar industry, and the iron and steel industry. In fact it may replace Sulphuric Acid in scores of uses. Salt Cake is a by-product obtained in the manufacture of Muriatic Acid. This material enters the manufacture of glass and of strong wrapping-papers. Salt Cake crystallized gives Glaubers Salt, which is used in the dyeing process of the textile industry. Bauxite treated with Sulphuric Acid makes Sulphate of Alumina, invaluable in the filtration of water and in the manufacture of paper. Gas from distillation of coal treated with Sulphuric Acid produces Sulphate of Ammonia, an important fertilizer. Nitrate of Soda treated with Sulphuric Acid gives

CONTACT ACID PROCESS BLOWERS

The blowers shown in the foreground have a capacity of seven cubic feet per revolution and are rated at two hundred revolutions per minute.

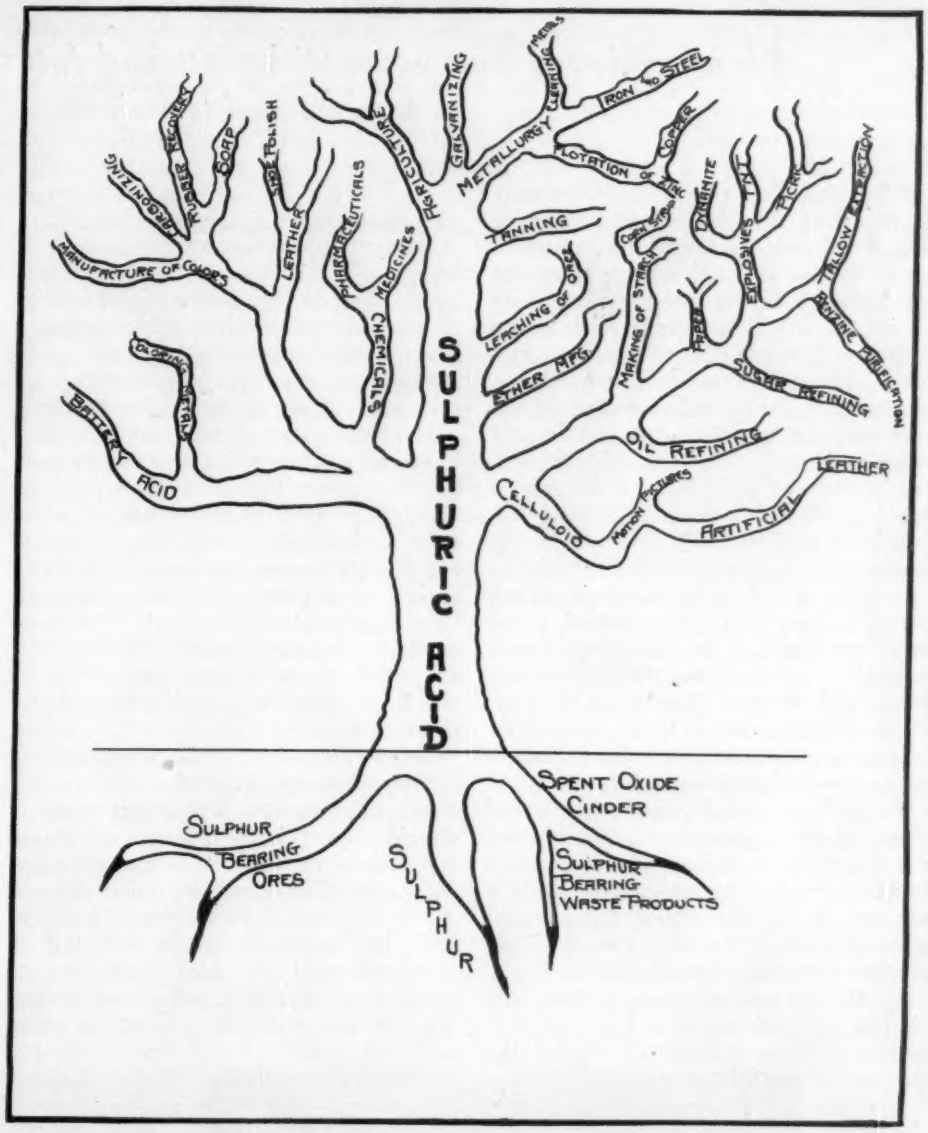
Nitric Acid, important to the dyer and engraver. Nitric Acid itself mixed with Sulphuric Acid forms Mixed Acid, used in Nitrating Cellulose. This is the base of artificial leather, pyroxilin, celluloid, and explosives. Sulphuric Acid with various coal-tar products produces many dyes and intermediates. With the mixture of Sulphuric Acid, Salt, and Acetate of Lime we have Acetic Acid, the important uses of which are in the manufacture of solvents, paint, varnish, perfumes, and drugs, and in dyeing.

Enough for the uses of Sulphuric Acid and its kin. Think, for a moment, of any manufactured article. In ninety-nine cases out of a hundred it is somewhere connected with Sulphuric Acid.

History and Manufacture

Sulphuric Acid has been known for centuries. It was first made commercially in England about 1750, and in the United States, in Philadelphia, at the Harrison Plant, in 1793. The first year's production by the Harrison Plant was about thirty tons. The acid is an oily, strongly corrosive liquid, colorless in its pure state, but easily contaminated by organic matter, which quickly changes the color to dark brown. It has great affinity for water, and when the two are mixed the acid quickly absorbs the water with great evolution of heat. In its weaker strength it rapidly attacks steel, aluminum, and many other metals, with the exception of lead and platinum. In the higher strengths, that is, sixty-five per cent acid and above, its action on iron and steel is slow. Contrary to expectations, the stronger acids are practically harmless to these metals — commercial acids seventy per cent and above are shipped safely in steel tank cars. A manufacturer received a complaint from a customer using Sulphuric Acid for pickling steel. "Your acid is weak and won't do the work; even after our operator has used double quantities in the bath it still won't do the work." It was found the operator's mistake was in having the acid too strong in the beginning and in adding acid instead of water, as a striking peculiarity of the product is that, above certain strengths, increasing the concentration lessens the corrosive action.

In another way Sulphuric Acid is peculiar. The freezing-points of most liquids change with regularity according to their concentrations. It is not so with this acid. The freezing-point of Sulphuric Acid at one per cent concentration is 31.2° above zero, Fahrenheit. The stronger the Sulphuric Acid becomes the lower the freezing-point becomes until it reaches about thirty-eight per cent concentration. For some reason, beyond that strength the freezing-point rises until the concentration reaches fifty-six per cent, when it rapidly drops again to sixty-eight per cent. Then it quickly rises to eighty-five per cent, where it will freeze on a spring morning with the temperature 46° above zero. Again it drops, until at ninety-six per cent it can be exposed to 29° below zero without freezing. Fickle in its relations to iron and to heat!



TREE SHOWING MANY USES OF SULPHURIC ACID

The freezing-point of Sulphuric Acid has a great deal to do with the method of shipment. The commonly used commercial strengths are sixty-five per cent, which is 53° Baumé; seventy-five per cent, which is 58° Baumé — both of these are called Chamber Acid; and ninety per cent, which is 66° Baumé, called Oil of Vitriol. These strengths do not freeze until they reach a point far below zero. They do not attack iron to a marked degree, therefore steel tank cars may be used by the large consumer instead of the customary glass carboys. Naturally it is to the advantage of the buyer to pay freight on as little water as possible, and so he buys the stronger acid when he can, although where the freight is not an important item it may be to his advantage to use Chamber Acid.

Process of Manufacturing

The processes of manufacturing Sulphuric Acid are two. Firstly, the roasting of sulphur-bearing ores in furnaces, and treatment of the gases in large lead chambers with water vapor and nitrous gases. This produces "Chamber Acid." This process is used at smelting-plants and in metal refineries, where waste Sulphur Dioxide gases must be recovered. The largest production of Sulphuric Acid comes from the chamber process. Secondly, the contact process. By this process any concentration of the acid may be made. The combining of the gases,

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The Story of Glass

A brief review of past accomplishments and future possibilities in both product and technique

By KARL L. FORD, '18
Chemical Engineer, The Glass Container Association, New York, N. Y.

GLASS has played an important part in the development of science and the welfare of mankind. It has assisted science to study the Laws of Nature by supplying in its various forms the tools which made possible investigations of all sorts. As window glass it has given man a means of building a home into which the sunlight can bring warmth and light, yet keeping out the chilly blasts. In the form of light bulbs it has given man artificial light to increase the hours of active work and play. As lenses, glass has opened up the heavens and that world of minute organisms which bring disease, from which valuable information has been gathered beneficial to mankind. The peculiar properties of glass have given it wide application, so that it has entered into almost every phase of the development of modern civilization.

In the earliest days of the history of glass, the similarity to minerals and the exquisite coloring possible made it specially adapted to jewelry. Beads appear to be the oldest samples of glass which are known to exist. This earliest glass was crude in form. Probably the process of manufacture was simply the melting of a few raw materials to form a lump of crystal-like substance, which was then ground into shape. From this simple beginning the next step was a hollow article formed by a molding process, forming a crude vase. It is a question whether these early forms were true glasses, but from the evidence now available it is certain that some form of glass or glaze was used over three thousand years ago. In the Metropolitan Museum of Art there is a glass necklace of Princess Mait dating back to the year 2160 B. C. These ancient glasses were opaque and colored.

The earliest forms of glass having any utility were vases, used principally for holding wines, and limited to the wealthier class. From the tombs unearthed in the ruins of ancient Egypt many articles have been recovered. Many of these are vases of elaborate design, highly colored, dating back to the eighteenth dynasty (1684 to 1591 B.C.). However, during this period some sort of molding process was employed, for the art of blowing glass had not been discovered.

There is a classical story told by the historian Pliny which may be only a tradition, but nevertheless it has certain facts behind it. According to Pliny, several Phœnician merchants built a fire on the sand along the river Belus. In the ashes they found a substance which resembled glass. Glass is not found in Nature to any extent. Even if some material resembling glass had been discovered it would have offered no indication to the men of that period as to the method of formation. It is probable that an event such as is described by the historian did furnish the suggestion that by the fusion of sand and soda a substance like glass could be formed. Then, as further substantiation of this story, a very high grade of glass sand, alkali in the form of marine plants, and abundant fuel existed.

With the advent of the blow pipe or putty, glass-making took on an entirely new aspect. The exact date of the introduction of the art of glass-blowing is indefinite. Some evidence indicates that glass was first blown about the time of Alexander (323 B.C.). This improvement in the working of glass afforded the real beginning of glass manufacturing. The next step was the use of molds to form the glass as it was blown. From this point very little progress occurred for a long period. Greater skill and a greater variety of application resulted, but the methods remained substantially the same.

Rome took over the glass industry and transported glass-workers from Alexandria about 14 A.D. Under Rome the glass industry reached a high state of development. While glass was used to some extent as window glass and for crude optical instruments, it had extensive employment for personal adornment and for domestic uses. One of the principal applications of glass jars during the Roman period was the storing of wines. It is evident that the Romans prided themselves on the antiquity of their private stock, for labels were found giving the age of the wine. The cutting wheel came into use and great proficiency was attained in the manufacture of cut and engraved glass.

After the Fall of Rome the glass industry suffered a decline. In Spain, France, Germany, and England the art was continued on a small scale. Very little is known concerning this period. The influence of the church in France accounted for considerable progress in the production of stained-glass windows. During the Middle Ages glass-working was considered a magic art. There appear in the writings of the alchemists evidences that they considered the remarkable changes which occurred when the crude, raw materials were transformed into a clear, transparent substance, with colors obtained by the additions of various ingredients, as a step toward the discovery of their dream of converting baser metals to gold. It is from their writings that many of the formulas for glass are obtained.

The Venetian glass-workers, early in the fourteenth and fifteenth centuries, assumed a place of importance in the commercial world as glass-workers. They acquired great proficiency in the production of art glass. Even to the present day their glasses cannot be surpassed. It is to the Venetian skill that we owe the invention of clear white glass. The Island of Murano became the center of the glass industry, and the glass-workers were given special favors from the government. Their product was sought from all parts of the world. Inspired by the Venetians, glass-making assumed a new lease of life, and by the sixteenth century it became a flourishing industry, with the methods of the Venetians replacing the cruder methods of the earlier workers.

Each country developed its own peculiar phase of the industry according to the needs and characteristics of its people. The French people specialized in fine mirrors and plate glass, which found application in the fancy coaches of that period and the ballrooms. Encouraged by the needs of the church, stained glass reached a high order, and France became famous for the stained glasses found in the cathedrals. An entirely different phase of glass-making received emphasis in Germany. Here the scientific bent of the people brought about a development in the field of optical glasses. Bohemian glass-workers held the foremost place in the manufacturing of table-ware. For a long period the clear crystal glasses of the Bohemians remained a standard for chemical glassware. It maintained a prominent position until very recently. In Austria colored glasses and imitation jewels were the principal product of the glass-workers. England developed the flint glass, so called because of the special sand used, specializing in containers and window glass. The Venetian glass-workers became highly proficient in the art of decorative glassware.

Even today this type of glassware holds a position of importance in the commercial world for decorated glassware. The Venetians and the Bohemians attempted to retain the secrets of the art in their own country, and heavy penalties were inflicted on those who went abroad to teach the art to foreigners.

To follow the manufacturing of glass through its development is to read a romance. Secrecy has been prevalent in every instance and some parts of the art have been lost. The early alchemists' records contain formulas which are absurd, and many of them are tinged with the magical beliefs of that period. But gradually, in the eighteenth century, scientific methods of attacking the problems of glass-making were evolved and sound facts obtained regarding glass. In many cases at first these were small experiments of an individual, the results of which were passed on to a member of his family. Various concerns endeavored to carry out experiments to perfect their product, with remarkable results. The history of early advances in glass manufacturing is the history of a few firms who developed glasses for special purposes and finally became famous for their product. The first researches of any consequence to be presented to the industry as a whole were those of Abbe and Scott. Their information dealt with the manufacturing of optical glass and the elements capable of being used in such glasses, considering their effect upon the optical properties. This work gave the art of lens-making an impetus which carried it to a foremost place as an industry. The World War inspired renewed researches in optical glass with noteworthy results.

The early attempts at glass-making were dependent upon the raw products and the fuel available. The glass plants used wood as a fuel in their furnaces. An interesting account of the operation of one of the earliest furnaces tells of the men whose duty it was to run around the furnace at a definite speed with a load of wood, tossing in a piece through the open doors. Two men kept this up during their hours, and they were relieved by two more who took up the task. Many of the earlier plants were located in the forests, where there was an abundant supply of wood. The composition of the earlier glasses was due more to chance than design, as it depended upon the materials available, the exact nature of which was unknown to the glass-maker. Some of this glass, in the form of window-panes, possessed a high resistance to the action of the elements. Some of the present glasses are approaching this glass composition in the attempt to produce a highly resistant glass.

No detailed record is available concerning the efforts to adapt improved methods to the art. A Frenchman conceived the idea of using a bellows to replace the lung power of the workers. This is very likely the earliest attempt of machine-blown glass. The mold changed from a crude clay form to wood, and then metal, in the present hinged form which is part of the automatic machines. In an effort to eliminate the mold marks a paste is employed and the mold revolved as the glass is blown in the mold. This method gives us the incandescent light bulb.

There are several inventions which mark definite steps in the development of the glass industry. The gas producer and the regenerative furnace brought about revolutionary changes in the melting of glass and made possible rapid strides toward increased production. The old-style pot furnace, with a number of pots, each of which had to be replaced at frequent intervals with considerable difficulty, is very little used. It is confined to those phases of the industry where pot glass is still necessary, due to the small quantity of the melts or the methods of manufacture. In its place, for bottle, window, and plate glass, has come the continuous tank furnace. This type of furnace consists of a large tank, through the upper part of which the products of combustion pass, heating the glass below. In one end the raw products are fed and at the other end the molten glass is drawn for the

(Continued on page 200)

INTERIOR OF MODERN GLASS PLANT

The working end of the glass tank is shown. The conveyers are carrying the bottles to the lehrs.

Catalysis—the Modern Philosopher's Stone

A survey of recent developments in one of the most important fields of applied chemistry

By H. W. Underwood, Jr.
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IN the Middle Ages alchemists zealously sought the philosopher's stone, which was expected to work wonders of many kinds. It would change the baser metals to gold by contact, it would heal all diseases, and even regenerate the character of the fortunate discoverer. Today chemists realize the absurdity of these fantastic ideas, but they talk about the transmutation of elements and the use of catalysts which are wonder-working stimulants for chemical reactions. A catalyst has been defined as a substance which changes the speed of a reaction, either positively or negatively, without itself being permanently altered in chemical composition. A very small amount of a catalyst will transform large quantities of reactants. Catalysis is used in practically every branch of chemistry, and without it many important industrial processes could not be operated economically. In this paper an attempt has been made to give a brief account of the more important recent practical developments in this field.

Synthetic Methanol and Acetic Acid

For a long time it has been realized that theoretically it should be possible to add hydrogen to carbon monoxide and thereby produce methyl alcohol, but until very recently all attempts to do this failed. A short time ago there appeared several accounts of the successful synthesis of methanol from water gas. Although all the details are not available, the essential features appear to be the treatment of one volume of carbon monoxide with two of hydrogen under a pressure of 150-200 atmospheres, at a temperature of 300°-450° C., and in the presence of a catalyst consisting of copper or copper oxide mixed with the oxide of zinc or chromium. A copper or aluminum lined steel apparatus is employed. Laboratory experiments indicate that it may be possible, by the use of a catalyst made from iron and sodium carbonate, to obtain a liquid called "synthol" (a mixture of alcohols, aldehydes, and ketones), which resembles gasoline in its properties. The importation of cheap, synthetic methyl alcohol has made those connected with wood distillation processes realize that they must meet keen competition.

The manufacture of acetic acid from acetylene constitutes another attack on the wood distillation industry. During the World War large quantities of acetone were made from acetic acid, which was produced through the oxidation of acetaldehyde by means of air, with manganese acetate as a catalyst. Acetylene was hydrated to acetaldehyde by means of dilute sulphuric acid and mercury oxide. Although these operations were regarded as a temporary war measure, the process has thus far been successful in times of peace.

Oil from Coal
Hydrogenation of Naphthalene

Several European nations have long been interested in the manufacture of oils and motor fuels from coal. Research has been devoted chiefly to the partial liquefaction of coal through hydrogenation under pressure in the presence of catalysts, such as nickel. Articles published a few months ago described the so-called Bergius process. Pulverized coal mixed with oil or tar is heated at 400° C. in an atmosphere of hydrogen and under 150-200 atmospheres pressure. The black, tarry liquid thus obtained is refined to produce motor fuel and other oils. Some writers state that one ton of coal will produce fifty gallons of gasoline. Although the process must be considered as one of the possible methods for making a petroleum substitute from coal, it is still in the experimental stages, and there is not enough information available to justify prophecies.

Among the new organic chemicals manufactured in 1924 and 1925 are two water-white liquids known as tetrahydronaphthalene or tetralin and hexahydrophenol or hexalin. These compounds are made from naphthalene and phenol respectively through the action of hydrogen under pressure and in the presence of catalytic nickel. Tetralin has found use as a substitute for turpentine and as a component of a motor fuel mixture containing also benzene and alcohol. On account of its comparatively low volatility, hexalin is added to the ordinary volatile solvents employed for nitrocellulose lacquers; it also serves as a detergent and as a solvent for a wide range of gums.

Petroleum and Derivatives

In the past, petroleum refining has been largely physical in character, and carried out with the sole aim of obtaining motor fuels, burning and lubricating oils, and allied substances. Those who keep in touch with recent journal articles realize that organic chemistry is being used more and more for making new and valuable products from petroleum, which offers many possibilities as a source of organic compounds. For several years isopropyl alcohol has been manufactured on a large scale by the treatment of propylene, a by-product in oil cracking, with sulphuric acid and water. Investigators are now studying cracking by catalysts and under exact conditions with the object of securing unsaturated hydrocarbons for the production of butyl, amyl, and hexyl alcohols and ketones of high molecular weight. All of these compounds are valuable solvents, and some may serve as starting-points for the manufacture of other substances. A short time ago there was described a scheme for passing the vapors of cracked gasoline through catalysts, such as fuller's earth, which absorb materials like the diolefines and polymerize them to higher-boiling products which can be separated by distillation. After the removal of these unstable constituents, the gasoline is more stable to light and has a lower gumming test and iodine number. By such a procedure it is possible to get satisfactory gasolines and burning oils from pressure distillates without acid treatment.

There are many questions connected with petroleum chemistry in the solution of which catalysis may play a part. What causes the darkening and gumming of cracked gasoline and the development of acidity on standing? How can these conditions be remedied? Have the possibilities of catalysis in the cracking of petroleum been exhausted? How can the production of polymers from cracked oils upon sulphuric acid treatment be best controlled and utilized? Is it possible to make cyclic hydrocarbons economically by cracking?

Phthalic Anhydride

Phthalic anhydride is an important intermediate for the manufacture of vat dyes for cotton and acid alizarin colors for wool. Formerly phthalic anhydride was obtained through the oxidation of naphthalene by means of fuming sulphuric acid and mercury salts as a catalyst. American chemists have devised an entirely new process which is superior to the old scheme and which produces a very pure and cheap product. Naphthalene vapor mixed with air is passed over vanadium and molybdenum oxides which act as oxygen carriers. By careful regulation of the temperature of the catalytic surface and the time of contact, very good

(*Continued on page 210*)

Recent Books

This department conducted in co-operation with the Technology Library

Shale Oil. By Ralph H. McKee, Ph.D., LL.D.; S. C. Ellis, M.E.; M. J. Gavin, B.S., M.E.; R. D. George, M.A., LL.D.; R. T. Goodwin, Ph.D.; W. A. Hamor, M.A.; L. C. Karrick, M.S., and E. E. Lyder, Ph.D. New York: Chemical Catalog Company, 1925. 326 pp. American Chemical Society. Monograph Series.

In this volume the authors have attempted to bring together such information as will give the reader a true and correct view of the shale oil situation and to furnish to the worker in this field a knowledge of what has been recorded in the printed word relative to shale oil. With this last idea in view, an entire chapter is devoted to a very complete list of article abstracts relating to shale oil. Another chapter is devoted to a collection of patents in the shale oil field, including brief abstracts of foreign patents.

The earlier chapters of the book deal with the origin, geology, and distribution of oil shales, and include a short account on the industry in general, together with a discussion of the most important methods of meeting a shortage of gasoline and petroleum, which, the author believes, is not far in the future.

A very comprehensive chapter on kerogen, the oil-yielding material of oil shales, is written by Prof. Ralph H. McKee of Columbia University and Ralph T. Goodwin of the Standard Oil Company of New Jersey. The chapter includes a discussion of the chemical composition of oil shale, together with chemical analyses of various shales; a study of the cracking of the oil during retorting and a microscopic study of typical oil shales.

The last chapters of the book deal with the more practical phase of the industry, and include a discussion on the refining of shale oils and a description of American experimental oil-shale distillation plants. Another chapter is devoted to some very interesting economic considerations of the shale-oil industry. The writer of this chapter believes that the United States must, in the near future, lose its supremacy in the petroleum world and become more and more dependent upon the oil resources of other lands, except in so far as the situation may be saved by the successful industrial production of an artificial petroleum.

Such a book as this represents a tremendous amount of study, with a very high degree of specialized skill on the part of the authors. Inasmuch as it presents the knowledge available on the industry in a readable form, intelligible to those whose activities may be along a wholly different line, it serves well the purpose of the monographs.

Modern Practice in Mining. Vol. I, Coal; Its Occurrence, Value and Methods of Boring. Vol. II, The Sinking of Shafts. By Sir R. A. S. Redmayne, K. C. B. 3d Editions. London, New York, Toronto, Bombay, Calcutta, and Madras: Longmans, Green & Co., 1925. $3.75 net per volume. These two volumes, originally appearing as first editions in 1908 and 1909, respectively, are parts of the set, all by the same author, dealing with the entire subject of coal-mining. Of this set four volumes have appeared to date and a fifth is in preparation.

At the outset the author frankly states that in the case of Volume II the present third edition is practically a reprint of the previous edition. For Volume I advantage has been taken of the opportunity to bring statistical figures up to date and make slight changes in some tables and calculations. In addition, however, a new chapter on Recent Boring Practice contains later data on this division of the subject.

Little in the way of comment can be added to what was said sixteen and seventeen years ago of the earlier editions, which were enthusiastically received as the latest, most comprehensive, and best-written books of the subject. Progress has been made in this interval. Yet most of the material is still standard and suitable for the mining student. The mining engineer who is always looking for the very latest developments may wish that the author had made a greater revision. This is particularly true of the American engineer, who will find that the author has dealt more with English and Continental practice, with only occasional reference to practice on this side of the water. One example of this is in the description of piston types of rock drills, which are now practically obsolete in America. Many of the English coal-mining terms which are employed extensively in the text are foreign to the vocabulary of our coal men, and form a source of difficulty for our students.

On the other hand, one cannot fail to appreciate the thoroughness with which the author has described and illustrated the various apparatus, notably the many methods of surveying bore holes, the various systems of shaft sinking under different conditions, etc.

As a fellow author who has recently completed the entire revision of a text-book on a subject allied to mining, the writer of this review is in a position to appreciate the magnitude of the task, and this was undoubtedly one of the main reasons why Professor Redmayne allowed the third edition to appear with so few changes. The profession will be far better served by having him devote his entire energies to the completion of his plans for the full set of volumes, with the hope that when this is done his years may be lengthened to allow extensive revisions of the earlier volumes as new editions become necessary. CHARLES E. LOCKE, '96.

Profitable Science in Industry. By D. T. Farnham, J. A. Hall, R. W. King, and H. E. Howe. New York: MacMillan Co., 1925.

Few books that come to the Institute Library make their appeal, as does this, to practically every student, in whatever course. In it will be found most interesting and even thrilling accounts of the discoveries made on behalf of industry through the patient investigations of scientists seeking ever to improve old processes and discover new. The stories are here told again of the discoveries in such fields as the production of non-corrodible metals and of self-lubricating metals for bearings, the pumping of sulphur from deep deposits, the development of the electric furnace, etc. Here are given facts that every educated man ought to know.

Says President Stratton, in a foreword to this book: "Men thoroughly trained in the methods of research and well grounded in the natural sciences and related knowledge are the greatest need of the day."

Students of the Institute, striving now to qualify themselves to fill this need, will find this book suggestive and inspiring.

Vision by Radio: Radio Photographs, Radio Photograms. By C. Francis Jenkins, 1925. 140 pp.

This little book has just been privately published by the author, who is the owner and director of the Jenkins Laboratories, Inc., in Washington, D. C. Following in the steps of Korn, Rignoux, Fournier, Belin, and others in the work of developing apparatus for the transmission of photographs by wire and without wire, Mr. Jenkins succeeded in producing the first photos by radio. He here details in simple language the history of the production, the description of his apparatus, and his prophecy for its future development. He believes that the control of light at distant points is the next great advance in electricity. The book is well printed and plentifully illustrated, and accordingly offers an attractive start in individual study of this new electrical marvel.

Illuminating Engineering. Edited by F. E. Cady and H. B. Dates. New York: Wiley, 1925. 286 pp. 162 figs.

Edited by Francis E. Cady (M. I. T. 1901), Manager of the Research Service Dept., Nela Park, and Henry B. Dates, Professor of Electrical Engineering, Case School of Applied Science, this book comprises lectures given by specialists in the course in Illuminating Engineering at the Case School.

Admitting with the editors that the entire subject of illumination could hardly be treated exhaustively in one volume, the scope of the lectures in question has been treated in a manner sufficiently analytical to result in a comprehensive survey of the principles underlying the production of light and its applications without enlarging upon the details of the applications. Chapter 1, Physics of Light Production, and Chapter 2, Light Sources, are particularly complete. Each chapter through the book concludes with suggestions for collateral reading, and some problems, thus placing the volume in the textbook category for which it was primarily intended and for which it seems aptly fitted.

Economics of Public Utilities: A Reference Book for Executives, Investors, Engineers, and Students. By L. R. Nash. New York: McGraw-Hill, 1925. 430 pp.

Mr. Nash, public utility engineer of Stone & Webster, Inc., and lecturer of note on public utility subjects, makes in the publication of this volume a valuable contribution to the steadily increasing literature on public utilities. Its chief value lies in its non-emphasis of any particular phase of public utility engineering and its comprehensiveness in covering all fundamental data and principles of this field. The public utilities considered are limited to electric light and power, electric railway, and gas, since these have to a large extent similar problems and conditions which may also be applied to other utilities.

The book is equally applicable to classroom use and general reading. Its concise, non-technical language offers an exposition, at once exact and interesting, of the fundamental facts about public utilities with which every citizen should be familiar.

Port Development. By Roy S. MacElwee. 1st Edition. New York: McGraw-Hill Book Co., 1925. 456 pp.

Several years ago Dr. MacElwee published his "Ports and Terminal Facilities." Since then the science of port development has grown so rapidly that a new edition has become necessary. The enlarged material, however, is to appear in two books instead of one. The present volume deals with economic problems such as government administration, promotion of port business, physical advantages, traffic advantages, port competition, free ports, etc. Later there will appear a revised edition of "Ports and Terminal Facilities," dealing entirely with problems of engineering and operation. Both these books are important, and no student of the problems of commercial development can afford to neglect either of them.

The Engineering Field

Excerpts from the leading professional and trade journals

A New Flight Principle. One of the graduate students in the Aeronautical Engineering Department last year was Mr. Heraclio Alfaro of Madrid, who was long associated with Spanish aeronautical enterprises before coming to this country. One of the last things he did before coming to Tech was to carry through the mathematical calculations in connection with the design of a new type of plane devised by Captain Juan de la Cierva. During the last year Mr. Cierva has further developed his invention, and recently tested it with great success at the request of the British Air Ministry at Farnborough.

Although commonly mistaken for a helicopter, the new plane employs an entirely new principle. The lifting element consists of four airfoils mounted on a vertical shaft above a conventional fuselage in the manner of a large airscrew. The assembly is free to rotate on the shaft, however, having no connection with the power-plant which drives a tractor propeller in the ordinary way to maintain a forward velocity.

When the machine is in flight, the flow of air over the wind-vane, as the lifting airfoils are called, causes it to rotate with a normal velocity of 140 revolutions per minute. This rotation produces a lift as in a helicopter, but unlike the helicopter it derives its energy from the flow of air alone. The wings are connected to the vertical shaft by a hinge, and a system of wires, and shock absorber cords that permit a deflection of the wing tip in an up and down direction. It is evident that when the wing sweeps forward it will have a relatively greater air speed than when it is receding, and will consequently give a greater lift. However the hinge allows the airfoil to move up when it is going forward, thereby having the effect of decreasing the angle of attack, and permitting the wing to drop while receding, with a corresponding increase in the angle of attack. This system would create a greater lift on one side than on the other were it not for the fact that the rising of the wings as they advance is the equivalent of a banking angle which is so adjusted that the resultant of lift always lies along the axis of the shaft. Thus it is seen that the angle of attack is a function of the translational speed of the machine and the angle between its direction of motion and the plane of rotation of the blades, which allows a great range in speed and flying angle of the plane.

The method of controlling is the same as on an ordinary plane. A rudder and elevator are provided in the slip stream of the tractor propeller with the ailerons mounted on the ends of a horizontal spar passing under the fuselage, but the latter surfaces are seldom required in flight. Inasmuch as there is no rotation of the blades until there is an air-flow, the machine requires a run for a take-off similar to an ordinary plane. In practice the wind-vane is usually given an initial whirl by pulling on a rope wound around the shaft in the manner of a top, and with this initial lift the plane gets off rapidly.

The great advantage of the Autogiro, as the device has been named, is its ability to descend vertically with a dead motor. In landing, the motor is throttled and the plane allowed to descend on a steep flight path at a nearly horizontal attitude. As the ground is approached, the machine is pulled farther back, thereby increasing the speed of rotation, and the plane drops vertically to a light "cushioned" landing with no forward speed at all. Although the weight of the machine loaded is 1100 pounds, the rate of vertical descent is only seven feet a second. In normal horizontal flight the Autogiro attains a speed of 55 miles per hour in its present form.

The Earth Induction Compass. The object in developing this compass was to make one that did not embody the faults of the magnetic compass, which are, that it is greatly affected by metal parts near it, current-bearing wires, vibration; and after turns have been made, it takes some time to assume the correct reading. In the magnetic compass, the needle is allowed to align itself with the magnetic lines of force of the earth, but in the new instrument, a current is generated by rotating coils of wire in the earth's field. The direction of the field is determined by the amount of current generated at any instant in the various coils. So far, two types of this compass have been developed, a single and a double circuit.

In the single circuit, a drum-wound armature, equipped with a commutator similar to that used in a D. C. generator, is placed where the magnetic disturbance is minimum, and rotated, in the case of airplane installations, by a small propeller placed in the air stream. The current generated is carried to a galvanometer in front of the pilot, who rotates the brushes, by means of a controller on the instrument board, so that they are in contact through the commutator with a coil of wire in which no current is being generated.

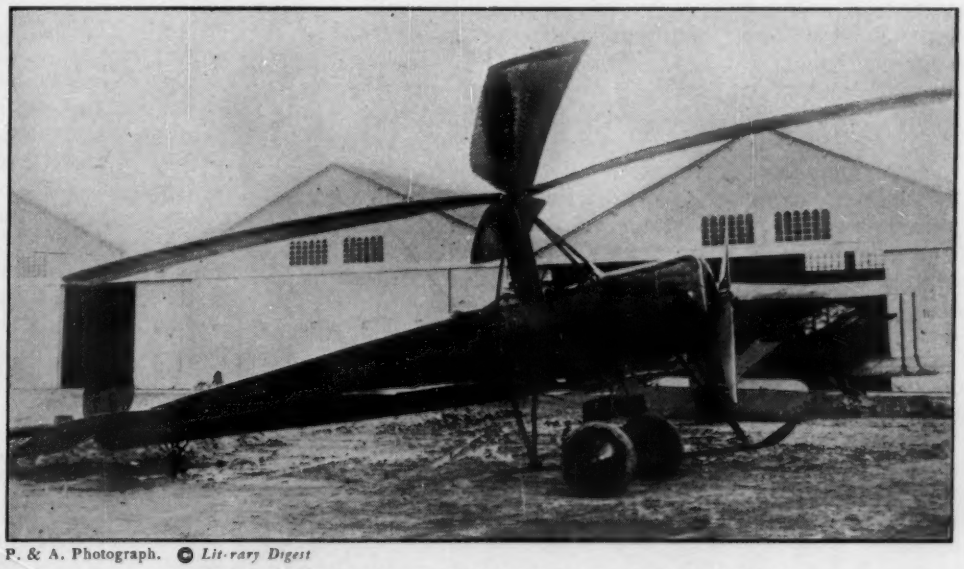
From the position of the brushes, the direction of the earth's lines of force can be determined. The position of the brushes with reference to the craft will then give the direction in which it is heading. In practice, the controller is so marked that when it is set to have no deflection of the galvanometer pointer, the course on which the craft is heading can be read directly. If the craft is turned to the right or left, current will be generated, and the dial will move to the right or left.

In the two-circuit type of induction compass, two sets of stationary brushes are placed 90° apart. The current from the four brushes is carried to the corners of a Wheatstone Bridge on the instrument board. By means of a rotating arm that makes contact with the bridge, current can be carried from any two opposite points to a galvanometer. The arm is rotated until no current is flowing through the galvanometer, and the heading of the aircraft is read directly from the dial. The rest of the operation is similar to that of the single-circuit type. These two compasses have an accuracy of 1.5° as compared with 5°, the limit of accuracy of the magnetic compass.—*S. A. E. Journal.*

Storage Battery Troubles Ended. The present-day storage battery has two great faults — spontaneous discharge on being left charged, and sulphating of the plates when it is left discharged. M. Charles Féry, a French scientist, has been carrying on research for several years to find the cause of this trouble and a possible cure. He has determined by careful work that it is oxygen dissolved in the acid which causes these two faults. In order to prevent oxygen in the air from dissolving in the acid and reaching the plates, he has proposed placing the negative plates at the bottom of the cell, and filling the cell with porous matter, similar to that in ordinary dry cells, which would absorb the acid. He has constructed batteries in this way, and found out that batteries left charged could remain over two years before they were completely discharged. Another battery was left discharged, and at the end of two years showed no trace of sulphatation, and was charged as any normal battery. This type of battery has not yet been produced commercially, but it is hoped that it will be on the market soon.—*L'Onde Electrique.*

Multiple Unit Motor. Louis Brequet, of the Brequet Company, has just designed an aviation engine composed of four eight-cylinder engines. Two of these engines are placed alongside one another directly opposed to the other two. Each unit is completely self-contained, having only the crank case in common with the other units. The crank shaft of each engine is coupled (by gearing) to a control shaft, on which the propeller is mounted. The coupling is so designed that any unit will be cut out in case of failure of some part, causing a drop in horsepower. The unit can then be repaired in flight, while the other three are running. With all four units in operation, the engine delivers over 1000 h. p. at 2100 r. p. m.

—*Automotive Industries.*



P. & A. Photograph. © *Lit·rary Digest*

"AN AIRPLANE WITH ITS WINGS CLIPT"—THE AUTOGIRO
Called "the most important step in aeronautics since the Wright brothers flew the first airplane."

Recording Varying Loads. An ingenious method of measuring electrical output under varying load conditions was used on a turbo-generator of the Interborough Rapid Transit Co. of New York. Portable indicating wattmeters did the measuring and movie cameras the observing. One wattmeter and one camera were used for each phase. The wattmeter was mounted vertically, with the camera focused so that the scale on the instrument covered the width of the film. The shutter mechanism of the cameras was operated in synchronism by a common motor-driven shaft. Number counters were so mounted on each instrument that the number appeared on the film, thus providing a means of identifying each picture. A watch was photographed at the beginning and end of each test to obtain the rate of observation. Mercury vapor lamps provided the illumination. Readings, obtained from the film after development by projection, were easily made to 0.1 small scale division of the wattmeter scale, which was 0.5 watt.—*Mech. Engr.*

Travertine Marble has become widely popular for interior decoration because of its buff tint and peculiar honeycombing of its porous parts; but, unfortunately, the natural stone is quite expensive. An imitation, closely resembling the travertine marble, may be made from a mixture of cement, sand, and a pigment, generally ochre. During the mixing process, hot paraffin is introduced and distributed irregularly throughout the mixture so that, when the cement has hardened, the paraffin may be removed by heat from a blow torch, thus producing the porous spots to which this stone owes its distinctive appearance.—*National Sand and Gravel Bulletin.*

Liquefaction of Coal. Because of the increased use of motor fuel and the threatened diminution of the available supply of petroleum, the problem of increasing the world's liquid fuels has become urgent.

Chemists in all countries have turned their attention to the mass production of vegetable growth, rich in carbohydrates, which might be transformed, by fermentation, into ethyl alcohol; but German chemists have concentrated their studies on converting coal into as large a percentage of liquid fuel as possible. Attempts to suspend finely powdered coal in oil have failed to furnish a satisfactory motor fuel. However, Dr. Gergius of Heidelburg, by heating finely ground coal, mixed with oil to prevent coking, in autoclaves, to 480°C. under a pressure of one hundred atmospheres, has succeeded in obtaining between forty-five and seventy per cent of the weight of the coal in oils, after the original coke-preventing oil has been removed. The total liquid product supplies gasoline for motor use, Diesel oil, and some heavy fuel oil. Since the operation lasts only fifteen minutes, and since the total cost of the product approximates ten cents per gallon, the process is of immediate importance in Europe, where the price of gasoline has always been relatively high.—*Chemical News (London).*

Lowest Temperature Yet. The Bureau of Standards, Washington, D. C., recently announced that the nearest approach to the absolute zero temperature which has yet been attained has been achieved by Prof. H. Kamerlingh Onnes, of the University of Leyden, Holland.

The record temperature of 272.18 below zero Centigrade, or .82 degrees absolute, was reached by the Dutch scientist in an unsuccessful attempt to solidify liquid helium. The temperature is equal to approximately 485 degrees below zero Fahrenheit. At this temperature, the liquid helium showed absolutely no tendency to solidify, according to the report of Dr. Onnes, who expressed the opinion that helium may remain a liquid even at the absolute zero.

This is within .82 degrees of the point at which we believe there is an entire absence of molecular motion.

Helium is the only gas that has, up to the present time, resisted all attempts at solidification.

Dr. Onnes, in his experiment, used the most modern apparatus obtainable, using a battery of twelve glass and six iron Langmuir pumps connected in parallel to get down to a pressure of only 13/1000 mm. of mercury in which to evaporate his helium.

Light Speed Checked to Nearest 25 Miles per Second. Dr. Michaelson, eminent University of Chicago physicist, in a report to the National Academy of Science, has announced his success in checking the velocity of light waves to a greater degree of accuracy than ever before.

The experiment consisted of flashing a ray from Mount Wilson to a neighbouring mountain peak and then reflecting it back again to the starting-point and measuring very carefully the lapse of time required by the ray to traverse the distance.

Powerful Microscope. The microscope used by Dr. Gye and Mr. Barnard in their cancer researches makes it possible to photograph bodies less than one-third the size hitherto regarded as the extreme limit of the powers of the microscope. Mr. Barnard's wonderful instrument photographs objects measuring only one two-hundred-and-fifty-thousandth of an inch.

Editorials

OUR PROFESSORS

Some of us, blinded by a pathetic wave of materialism, and misguided by the practical, are wont to look upon our professors as impractical men, living a narrow, one-sided life in a secluded dungeon of their own making. We shudder at the thought of their pouring over textbooks day after day, in order to eke out, what we are apt to think, a miserable existence.

Let us look upon the matter from another angle, from the viewpoint of the professor himself. He rejoices in his work, feeling that there can be no better task for humanity's cause than passing on the knowledge accumulated in past generations. It is his assigned task to see that this knowledge is imparted correctly and completely, and frequently it is a most trying one. The remuneration of his position cannot be an attraction; this has invariably been curiously inadequate and meager. It is a well-known fact that it is more profitable to draw comic strips than to write a scientific treatise. The gate receipts of an international prize fight would support a university faculty for a year. Yet in spite of this meager remuneration, our professors labor day after day, year upon year, consistently and unflinchingly. This is remarkable. Even more remarkable is the indifference of the world to the whole matter.

We quote a paragraph from "The Fifth Estate," which appeared some time ago in the *Atlantic Monthly* in this connection. "It is not becoming that the world expect the light to shine indefinitely when carrying a lantern is often less remunerative than carrying a hod. The money and the years of study required for special training are not recognized as invested capital, and the return from a decade of research is often taxed as the income of a year. Professional salaries move forward as slowly as a glacier, but they seldom leave a terminal moraine. *Yet teaching is our most important business; for a failure to pass on for a single generation the painfully accumulated knowledge of the race would return the world to barbarism.*"

Looked upon in this light, the work that our professors are doing is most laudable. Certainly the university faculties hold no place for those persons with a lassitude or a "get rich quick" complex. "Though material wealth is rarely acquired by them, they have the riches of the royal man, defined by Emerson as 'he who knows what sweets and virtues are in the ground, the waters, the plants, the heavens, and home to come at these enchantments.' Their wealth is in the kingdom of the mind. It is inalienable and tax-exempt. It may be shared and yet retained."

AGE AND YOUTH

It is with great pleasure that we reprint the following editorial which appeared in the *Engineering News-Record* some time ago. The meeting referred to in the editorial is the Engineering College Magazines Associated Convention held at Cornell University. THE TECH ENGINEERING NEWS is one of the twenty-one college engineering magazines in the association, and was represented at the convention.

"During the past week, an editor of *Engineering News-Record* had occasion to attend two meetings. At one, a succession of practising engineers, all at least twenty years out of college, asserted that engineering education is becoming mechanized, that the recent graduates are too technical and absorbed too greatly in the details of engineering minutia, that they all stand in need of wider outlook and broader background. The other meeting was a group of the editors and business managers of a score of the magazines published by the undergraduates of engineering schools. Throughout a busy day's session, these young men discussed the problems of their avocation. And from a long experience in attending technical meetings, this editor can say that never has he heard more direct, confident, precise, and clear speech than these same undergraduates used. What each had to say he said explicitly and stopped; repetition was rare, hesitation was nonexistent. Can as much be said of the average engineering meeting? Emphatically, no! And since the ability to think clearly and to express that thought succinctly is one of the best outward evidences of those qualities the engineers in the mature meeting found lacking in their younger brethren, the thought became inescapable that these gentlemen — who, indeed, were voicing a common enough thought among engineers — are attacking a straw man. . . ."

POWER

Provision of food, and protection from disease, from enemies, and from the rigors of climate, are as essential to man's existence today as they ever were. In civilized lands few die from starvation or exposure, and we are accordingly inclined to take food and shelter for granted. In prehistoric times, these issues were clear and direct. As time has gone on, they have become more complex, but always man's discoveries of the possibilities of his surroundings have kept him moving forward. Today the problems of food and shelter in the temperate and colder climates have become intimately connected with the problem of fuel. But in addition, the whole fabric of modern industrial life is founded on an adequate supply of power.

At present, fuel is the source from which the world derives the greater part of its power, but the types of fuel to which the world has grown accustomed are not inexhaustible. The history of wood as a fuel in the last few hundred years can be traced today throughout its course from the burning woodpiles of the Pacific Coast sawmills to the little bundles of wood sold in the old world for starting coal fires — waste to scarcity. Coal is still plentiful, but the rapid depletion of the higher grades is making necessary continual improvement in existing methods of using it, so that we hear much of "superpower," "low-temperature carbonization," and other schemes. The supply of oil is a debatable point for experts to discuss, but there can be no doubt as to the rate at which it is being used.

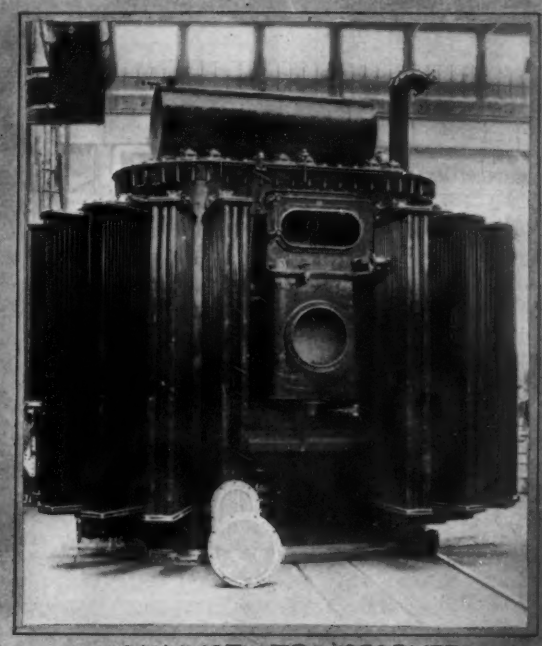
If sources of energy other than fuel be considered, we come at once to water-power, a matter, however, of charted and known possibilities and limitations.

This, briefly, is the power situation as it is today. Many other sources of energy are known to science, but so far they are not serious competitors of coal, oil, and water-power. Investigation is bound to become more intense as time goes on and needs become increasingly apparent. That the problems of the depletion of the world's known power supplies will be met as they arise, history gives us little reason to doubt. In the meantime, existing resources are in need of protection from the reckless waste that ignorance or hope of gain has engendered in the past. Whatever discoveries or developments are made, it is unlikely that they will lead to power which may be as casually obtained as it has been so far. Perhaps we may hope also, therefore, that the future may see progress in the direction of economical use of resources coming with the necessarily more careful organization for their development.

Whether it be in the discovery of new possibilities or in the development of existing ones, such great problems must give rise to great opportunities; such opportunities indeed as Mr. Frank Scott spoke of in his Aldred lecture.

DIESEL ELECTRIC LOCOMOTIVE

Eight car train in city limits where switching with steam locomotives is prohibited

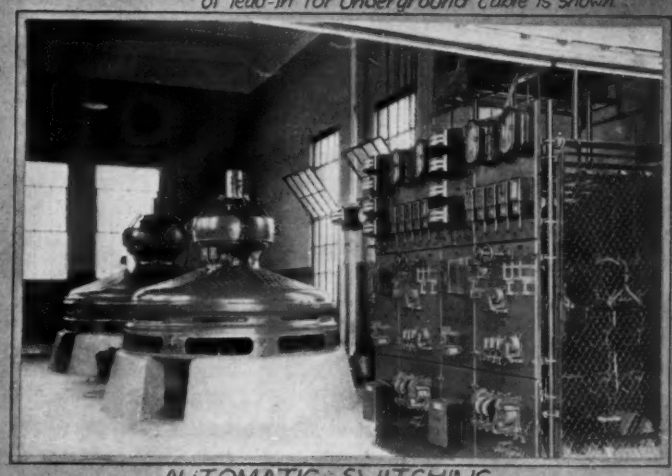


MAMMOTH TRANSFORMER

Pothead type, 10,000 k.v.a., 13,200-26,400 v. Unique type of lead-in for underground cable is shown

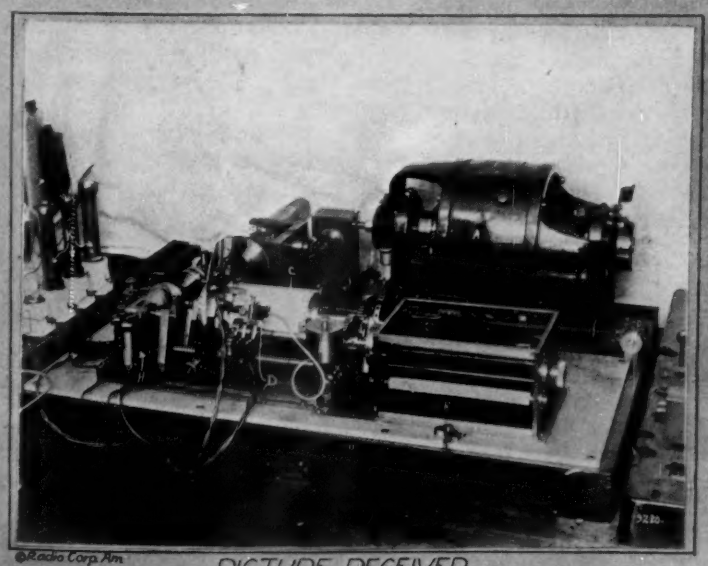
PORTABLE TRANSFORMER

Electric lumbering operations use this sturdy step-down unit. Capacity 600 kw. at 11,000-450 v.



AUTOMATIC SWITCHING

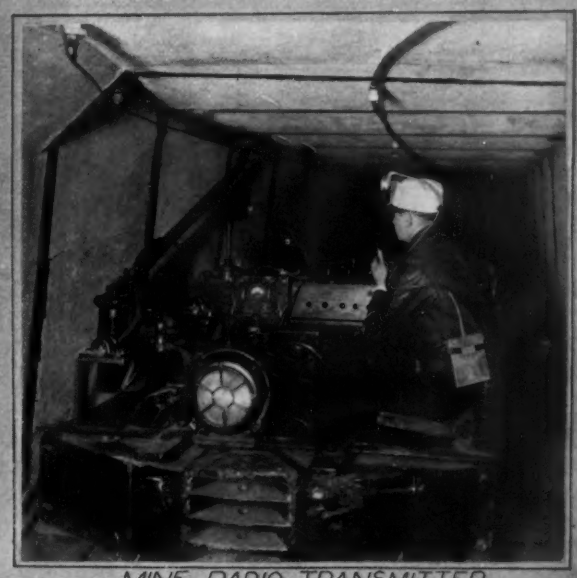
Waterwheel driven generators entirely controlled by automatic switchboard



©Radio Corp. Am.

PICTURE RECEIVER

This machine records the pictures received via radio



MINE RADIO TRANSMITTER

Rescue work is aided by unit mounted on mine locomotive

Professional Notes

Activities of the Undergraduate Engineering Societies at the Massachusetts Institute of Technology

ELECTRICAL ENGINEERING SOCIETY

O. M. Hovgaard, '26, was the speaker at the meeting of the Society held on Friday, November 27. The subject of his talk was the use of vacuum tubes for purposes other than communication. He described many of the more or less unusual uses to which the thermionic tube may be put, with particular reference to many applications which have come up in connection with the work of the Research Division of the Electrical Engineering Department at the Institute.

This was the first of a series of talks which will be given by students. Similar papers are in preparation by other students, and will cover the fields of the power system at the Institute, details of the new Richmond Station of the Philadelphia Electric Company, and commercial power factor correction.

The Society announces that at some time during the coming spring there will be held a convention of all the student branches of the American Institute of Electrical Engineers in New England and New York. This convention will be in many respects similar to the national conventions of the A. I. E. E., and will be run principally by students, with the co-operation of the Boston Section A. I. E. E.

CHEMICAL SOCIETY

The activities of the Chemical Society for the preceding month were limited to two trips to industrial plants in Boston. The first trip, which was held early in November, was to the Lever Brothers Soap factory. The members were given a very comprehensive insight into the manufacture of soaps, from the boiling of the fat, with caustic, in large kettles, to the packing of the product for market. Special emphasis was placed upon the method for recovering the glycerine from the salt lye. The members making the trip were each presented with full-size samples of the various soaps manufactured in the plant.

The second trip, held on Thursday, November 19, was to the Page & Shaw Candy factory in Cambridge. The members were divided into three groups of approximately ten men each. The cleaning and roasting of the cocoa bean, and the extraction and finishing of the chocolate, were first explained. The men were then shown through the candy factory. Although there was very little chemistry involved in the manufacture, the trip proved a very popular one with the members.

AERONAUTICAL ENGINEERING SOCIETY

A very interesting talk by Mr. Ralph H. Upson upon the construction of the proposed metal-clad dirigible was the program of the November 19th smoker of the Aeronautical Engineering Society. Mr. Upson, who is the holder of many prizes for free ballooning, including a first place in one of the international Gordon-Bennett contests, has recently devoted his attention to the solving of the constructional problems which have arisen in the design of the metal-covered airship.

The proposition calls for a vessel with an outer cover of thin sheet duralumin which will also take the place of the fabric of the gas cells, and have sufficient strength to take the loads normally disposed of through diagonal wires. One-sixteenth inch duralumin rivets were the smallest obtainable when the work started, but they were found to be far too large for strength and lightness. Eventually, the best size was found to have the same proportion to the thickness of the material, .008 of an inch, that standard ship plate rivets had to the plates they joined. The seams are sealed with a special gummy compound which will work into the open spaces even against the gas pressure.

Although the slimness ratio of the *Los Angeles* is considered low with a value of 7.2, the ratio for the new airship is only a little over 3. The center of pressure for the long ships is actually ahead of the nose, so that slight displacements tend to aggravate the angle of yaw, resulting in an unstable ship. With the short dirigible the opposite is true, the ship tending to nose into the gust or disturbance acting on her bow, thereby greatly reducing the bending stresses. The resulting chunky shape would at first appearance seem to give a higher resistance, but this is not true, for the skin resistance is decreased more than the impact resistance is increased. The use of a short hull also greatly reduces the weight.

CIVIL ENGINEERING SOCIETY

On Friday, November 13, the M. I. T. Student Chapter of the A. S. C. E. held its third meeting in Huntington Hall, Rogers. Mr. Dexter P. Cooper, engineer of the Passamaquoddy Bay Tide Power project, addressed an audience of more than five hundred engineers and engineering students of Boston colleges. He discussed the numerous problems in the preliminary design of the project, including the question of gates, turbines, dredging, and dams.

In speaking of the economic effect of a project which would develop nearly as much power as that used at present in all New England, Mr. Cooper alluded to the new era of mass production and the consequent decentralization of industry so freely predicted by economists in the past few years. He disavowed any desire to present his project as a cure-all for the economic condition of New England, but declared that the possibilities for cheap electric power opened by it should enable New England to successfully meet the new era.

NAVAL ARCHITECTURE SOCIETY

The Naval Architecture Society has taken two trips during the past month which were of great interest and enjoyment, and which will be, it is hoped, only forerunners to a varied and instructive program to be carried out in the coming year. With these tours of inspection the Society is looking forward to a year of greater activity, and hopes, through them, to foster the spirit of enthusiasm in its department.

The first of these trips was a visit to the S. S. *Boston* while it was out of water in Simpson's dry-dock at South Boston for repairs to its propellers. The members of the Society were given the opportunity of seeing the underbody of this twenty-knot vessel. They were shown the engine and boiler rooms, which were of particular interest in that they exemplify the modern type of twin-screw, high-speed, turbine installation. Piping systems were traced, the fire-room was inspected, and the switchboard examined.

It is the desire of the Society to include as many ships as possible in their excursions by reason of their supplementary value to the work in the classroom.

The second trip was made, under the supervision of Professor Owen, to the yacht yard of George Lawley & Son at Neponset. Although very few made the trip, each department of this complete yard was enjoyed. Yachts in various stages of completion were found in the shops, and many well-known craft were to be seen in the "fitting-out" basin.

During the coming months the Naval Architecture Society is planning to vary its program of trips by visiting such places as the Sturtevant Blower and Fan Company, the Weymouth Plant of the Edison Electric Company, a Diesel Engine construction company, and, if possible, the engine room of a motor-ship.

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Number 53 of a series

The Story of Glass

(*Continued from page 191*)

blowers or the machines. These furnaces resemble an open-hearth steel furnace, hold from 100 to 250 tons of glass, and have a life of from one to two years continuous operation.

Paralleling the development of methods of melting glass are developments in refractories. Better pots and quicker methods are available, thanks to scientific investigation. Tank blocks have followed the demand for longer life and increased temperatures of operation. The temperatures of a glass tank furnace vary from 2500° F. to 2900° F. One of the noteworthy developments in pot manufacture, which is a slow hand process, is the casting of pots.

The design of furnaces has changed as more information of an exact nature was obtained on furnace operation. From the simple wood-burning furnaces developed coal and gas fired furnaces, and lately oil has been employed. Combustion problems have been encountered and these are being solved by scientific investigations. The proper methods for mixing the air and gas and directing the flame are still under discussion, but enormous improvements are evident over the earlier methods. Electricity is being considered as a means of melting glass, and experiments are producing results in this field.

But the inventions which gave glass manufacturing the greatest forward thrust were those adapting automatic machinery to the blowing and working of glass. Hand-blown bottles and window glass require great skill and demand considerable sacrifice on the part of the workers because of the strenuous physical labor involved in blowing operations. This limitation placed on the workers necessitated a high wage, thus maintaining a high production cost for glass. With the introduction of automatic machines, hand labor was replaced by methods which gave more accurate and uniform products, and which placed glass manufacturing on a production basis never before realized. Machines were devised to accomplish the blowing of bottles, the blowing and drawing of window glass, and other operations which had previously required separate operations and many hands. The first successful bottle-blowing machine was invented by Ashley, of Castleford (England), in 1888. In Europe and America this machine was followed by others, but it was not until 1903 when Owens, in this country, perfected the complete automatic bottle machine. This machine takes the proper amount of molten glass from the tank and performs all the operation, delivering a finished bottle to the annealing lehr.

In the manufacturing of window glass it was necessary to blow a long cylinder which was split down the center and the curved section flattened by hand operation in a special furnace. Machinery was designed to blow this cylinder, but hand work was still required for the flattening process. A mechanical process has been devised which draws from the furnace a continuous strip of glass at a high temperature, passes it through rollers, where it is brought to the proper thickness, moves it through a lehr, still a continuous strip, annealing the glass, and finally discharges at the end a slab of window glass which has only to be cut into the proper sizes. This same method has been applied to the manufacturing of plate glass. The slabs of glass, after leaving the drawing machine, pass beneath the grinding and polishing wheels in a similar manner.

Glass-making was one of the first manufacturing enterprises of this country. In Jamestown, in 1607, a glass plant was established, and the following year glass bottles were exported to England. In 1621, Italian workmen were brought over to make glass beads, which were used to purchase land from the Indians. In 1639 a glass plant was built in Salem, Mass. However, the center of the glass industry moved to locations where fuel was more abundant and natural gas could be obtained.

Glass is an amorphous transparent substance the exact chemical and physical structure of which is little understood. The principal ingredients are sand, soda, and lime. Lead is used in place of lime in glasses intended for optical uses. Many other compounds are added to the batch in an effort to give the glass special properties. In considering the effect of different substances, the effects of various oxides have been studied and formulas have been developed for calculating the physical properties of the glass. The effects of the various components of the glass are approximately additive in character. The work of Abbe and Scott was the first to call attention to this feature, and later investigations have further developed this relationship. Special attention has been given to optical glass, and formulas of an extensive nature are available showing the relationship between the various ingredients and the index of refraction.

Another problem which has been studied in a scientific manner with results beneficial to the glass industry is the annealing of glass. As glass cools there is a chilling of the outer layers, reducing the viscosity below that of the inner portion, and as the outer layers are unable to become adjusted to the contraction of the other portions, strains are produced which tend to make the glass fragile. These strains are relieved by heating the glass to a temperature at which the mass will come to equilibrium and then cool through the annealing range at such a rate that no permanent strains will be produced. This process is absolutely essential to insure a stable product for most purposes. In the earlier days of the industry the hot article was buried in ashes and allowed to cool. Then a long furnace was employed similar to those now used, and the glass articles moved from section to section, gradually cooling. This accomplished a fair annealing. Now, with thermocouples to measure the temperatures, and modern methods of heating, together with scientific data regarding the annealing curves, excellent results are obtained with this type of lehr. A continuous conveyor moves the glass through the lehr. From the open-fired lehr has developed the muffle lehr, in which the products of combustion are not in contact with the ware. The latest addition to the modern methods of annealing is the electrical lehr entirely automatic in its operation. Electrical heating units along the lehr are controlled by thermocouples. With this type of lehr a close agreement is obtained between the actual curve of the lehr and the theoretical annealing curve for the glass. With these modern methods of annealing, commercial glassware is produced with properties which could only be found in chemical glassware of a few years ago. By use of polarized light in a simple instrument, the annealing can easily be checked, giving the manufacturer close control over his product. This is a long step from the days when two bottles were rubbed together, and if they broke, the temperature at the hot end was increased.

The modern glass plant controls the batch composition by chemical analysis of the raw products. The finished product is checked from time to time, and the furnace operation watched, and changes made in the batch, if necessary, to maintain a uniform product. In the batch house the proper proportions of raw products are weighed into cars which collect all materials for the batch. These cars

(*Continued on page 202*)

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Fig. 106
Screwed, Jenkins Standard Bronze Globe Valve

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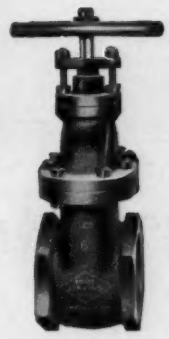

Fig. 325
Screwed, Jenkins Standard Iron Body Gate Valve

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POWDER MAKERS SINCE 1802

The Story of Glass

(*Continued from page 200*)

mix the materials and dump the mixture onto a conveyor which carries it to a bin above the furnace. In recent years the batch was mixed on the floor by shovels, and the charge to the furnace measured in the same manner. With no knowledge of the exact composition of the materials, troubles were encountered. The usual remedy was to increase the proportions of soda or increase the furnace temperature if possible. The elimination of bubbles from the glass presented another serious problem which even today is not completely solved. Now, scientific methods give the glass-worker means to follow every step in the process, and much more uniform results are being obtained, due to control of the composition, the annealing, and furnace temperatures.

To the most of us, whose experience in glass-working is limited to simple laboratory apparatus which was not completed without considerable breakage and struggle, it is an impressive sight to watch a machine draw from a tank of molten glass a gob of the proper weight, and then, with more than human ability, work this into shape and discharge a finished bottle. When we realize that this entire process must be accomplished within a definite temperature range of the glass, it is evident that many problems of heat flow were encountered.

The glass industry has been faced with many problems in its development and there are still more problems ahead. The effect of composition on the properties of glass, the annealing of the glass, and the working were considered first in a practical manner by the workers themselves. What information was obtained was kept as trade secrets. With the advent of scientific methods these problems have been considered openly, and handed-down formulas have been replaced by accurate data determined in the laboratory. Problems of heat flow in the furnaces and in the working operations, problems of viscosity, problems of annealing, and many others are ahead. In the container industry much work remains in the study of shapes of containers and the design of shapes which possess great strength. During the last century the greatest advances in the industry have been accomplished, but in a large sense science has only assisted in placing the industry under more efficient methods of control. The application of thermocouples and automatic controls, methods of determining composition, and methods for regulating the annealing have placed the industry on a sound scientific basis in many instances, but there are great possibilities for future development and greater application.

Glass enters into numerous phases of our daily life. It has reached a place of importance in this civilization which can hardly be measured. Glass enables the scientist to accomplish wonders in the laboratory. It has become a very common product which we could hardly do without. But to many the production is a mystery, or at least a very unfamiliar subject. The industry has freed itself from secrecy and formulas handed down from father to son and is entering a phase of development in which the scientific man, the engineer, is to play an important part. There are problems and opportunities for trained engineers worthy of any man, and it is hoped that they will receive the information during their years of study and training which will lead them to direct their efforts in this field.

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Sulphuric Acid—a Pillar of Modern Civilization

(*Continued from page 189*)

Sulphur Dioxide and Oxygen, is carried on in the presence of platinum, which is used as a catalyzer. Asbestos is treated with platinum to make a spongy "contact mass." Care must be taken not to poison this contact mass, for arsenic, flue dust, or other impurities will cause great injury, resulting in plant shut-downs. Brimstone in a pure state is now nearly universally used in this process. It has superseded pyrites on account of lower costs and because it is easily handled. Since the War large discoveries of native Brimstone have lowered its cost to a point where it is more economical than sulphur-bearing ores to ship, to handle, and to use.

The contact process had its origin about 1831. The experiments of Professor Winkler in 1878 focused attention upon it. It was found that the gas from burning Sulphur could be converted into Sulphuric Acid in the presence of Platinum. The complications of the process were first worked out and commercially used in Ludwigshafen, Germany, by the Badische Company. The contact process has entirely done away with the old, expensive concentrations of acids in platinum.

Relation to Heavy Chemical Industry

Only a small part of the Sulphuric Acid production of the United States goes onto the market, as most of the greatest consumers have their own Sulphuric Acid plants. Very few chemical plants produce solely Sulphuric Acid. It is a product that should be shipped reasonably soon after it is manufactured. To construct large tanks to hold the acid for long periods of time would be uneconomical. If a plant had nothing but Sulphuric Acid to sell, its operation would be affected by the ups and downs of industry in its neighborhood. As Sulphuric Acid is not an expensive commodity, and plants for its production are well distributed, it cannot bear the cost of long-haul shipments. In tank cars the price is approximately $16 a ton, and it is impossible for a manufacturer to ship this material far in the United States without entering the economic rail shipment radius of a competitor, therefore the manufacturer turns his surplus acid to the production of other chemicals. A great problem of the heavy chemical industry is to see that the plant is well balanced, that waste products of one process may be fully used in another process, and that all of the finished products are not greatly overproduced for the demand of their markets. The most efficient management, of course, is to use everything in the plant for some purpose. The odor of escaping gases indicates waste, and it is an urgent matter to recover these, not only to keep the manufacturer from defending nuisance suits, but also for the value of the gases.

In the Sulphuric Acid industry, as well as in other chemical industries, one of the most important problems is repairs. In an acid atmosphere machinery, buildings, piping, and wiring quickly deteriorate, making repair and depreciation items the largest with which to contend. Another big problem, possibly more vital to the heavy chemical industry as a whole than to the producer of Sulphuric Acid, is obsolescence and change of process. Many a manufacturer has installed a new process which soon has been rendered practically valueless through the discovery of a simpler or cheaper

(*Continued on page 206*)

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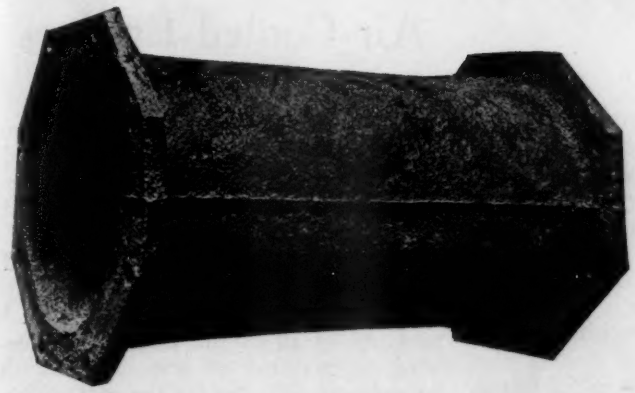

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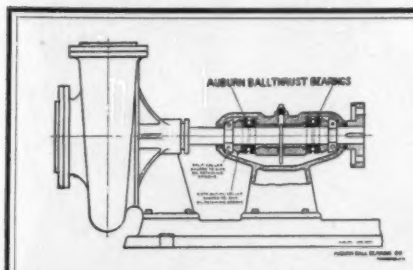
Sulphuric Acid

(*Continued from page 204*)

method. The chemical manufacturer is then in the position of the indigo grower when synthetic indigo was first used, and of the horn comb maker when celluloid was discovered.

How the eyes of the pioneer would gleam today if he awoke from a sleep which had lasted since 1794, when he had finished selling his thirty tons of acid in Philadelphia, and one hundred and thirty years later could see over the country two hundred and fifty plants, the smallest of which was hundreds of times his in capacity; if he knew that from his twenty-five to thirty ton annual output the Sulphuric Acid industry had grown to produce over seven millions of tons in the United States each year. These seven millions of tons of acid go into undreamed-of comforts to millions of people. They are making possible longer life, more happiness, more pleasures. They are safeguarding the welfare of the people in peace, and stand as the country's greatest bulwark in war. Truly the nation's first line of defense! The industry is only at the dawn of a greater usefulness. There is more future in the Sulphuric Acid industry than is at present imagined. There is a "Land of Beyond," unexplored, awaiting the pioneer. Let the technically trained research man enter, to wrest from it its secrets, with the spirit of the explorer, searching for the glory of finding and leaving to the millions that follow the benefit of his labors.



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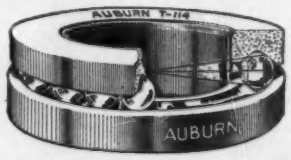

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Air-Cooled Engines

(*Continued from page 185*)

from the inside of the case while the engine is at rest, and which would otherwise overflow the lower cylinder barrels even though they are extended into the case. Aside from these differences, the engines are lubricated much the same as any modern aviation engine with approximately 100-pounds pressure to all of the major bearings. Various systems of gas distribution have been used. So far the most satisfactory for nine cylinders has been three separate three-cylinder induction systems consisting of circular manifolds with cylinder leads 120 degrees apart and each provided with its own carburetor. In this system, if a single inlet valve becomes inoperative, only three of the nine cylinders are affected. This arrangement has the disadvantage of considerable weight and complication. A modification has been used in which the three manifolds are connected to a single double-barrel carburetor. A third method of considerable promise is the rotary distributing system. In this system a single carburetor is used in conjunction with a small centrifugal blower from which the gas is taken tangentially to the various cylinders. The blower not only distributes the gas uniformly, but diffuser vanes thoroughly mix the fuel with the air and prevent puddles of fuel forming.

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(*Continued on page 208*)

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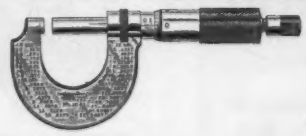

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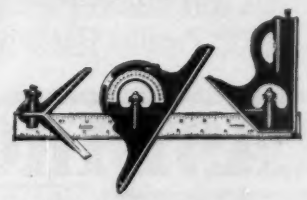

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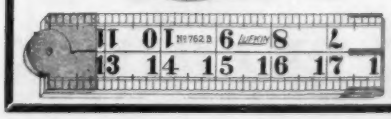

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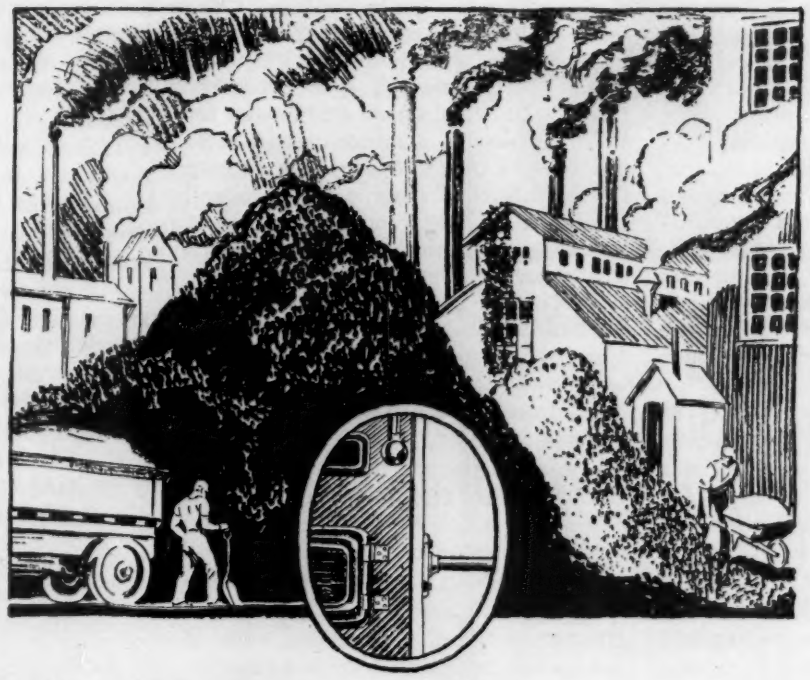

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A chimney or smoke pipe *leads away* from your plant and is an offensive waste pipe for your fuel. A gas service pipe *leads into* your plant, bringing to you only the amount of fuel that you can use to advantage.

You cannot get 100% return from any fuel—excepting gas. Gas Fuel comes to you through a service pipe, entering your plant in 100% usable form.

You pay for nothing which cannot be used. There is no chimney loss—no ash, cinder, smoke, soot or other waste product from gas. Gas Fuel is clean, efficient; requires no storage space and practically no operating space.

When you want gas, a turn of the wrist brings it instantaneously. You can control the flow of gas as easily and accurately as setting the hands of your watch. When you are through using it, turn it off and the expense stops.

Gas Fuel is paid for after it is consumed—no idle money is tied up in fuel for future use.

This efficient pipe service now brings to over 1600 industries in Boston approximately 75 million cubic feet of gas per month.

Modern industry requires above all else the elimination of waste and the utilization of every practice which will save time and energy.

Let Boston's Gas Company engineers help modernize your fuel system - - It costs nothing to investigate

Boston Consolidated Gas Co.

Air-Cooled Engine Development

(*Continued from page 206*)

ators and cooling water used with the water-cooled types. The modern air-cooled engine will give fifty to seventy-five thousand miles of service without a top overhaul. For equal powers, the performance of an airplane with an air-cooled engine is superior to that of the same plane with a water-cooled engine. Not only is there a considerable weight-saving in the power-plant, but there is a reduction in drag due both to the symmetrical form of fuselage and the reduced resistance of cylinders as compared with a water radiator.

The general use of these new types of engine has been greatly retarded by the large amount of surplus war material which could be had at a very low figure. The use of this material has encouraged flying, particularly in the Middle West, and has done a great deal to introduce it. It has likewise educated its users that a tremendous improvement was necessary in power-plants. Owing to the lack of Federal regulation, this war-time material is particularly dangerous in the hands of unskilled personnel, who have no idea of its proper maintenance or limitations. This is probably one of the most serious situations that aviation faces at the present time. Very few realize that, although it is necessary to have an examination and license for the operation of a motor-car, in most parts of the United States anyone may fly regardless of their experience and condition of their equipment. The unfortunate result of this condition is a number of preventable fatalities.

At present the surplus war material is nearly exhausted. Besides this, commercial operators have learned to appreciate the advantages to be derived from the operation of air-cooled engines, namely, increased dependability and greater pay-loads. As a result of these circumstances, the new equipment is slowly coming into general use. The expansion of the Air Mail will bring about the development of a reasonable number of widely scattered emergency landing-fields as well as navigation safeguards such as beacon lights and weather forecasts. Through the medium of carrying mail and merchandise, these requisite ground organizations will be established so that safe passenger traffic may follow.

Water Supply

(*Continued from page 187*)

location, other sources of supply must be found. The growth of the city since the first Croton water was introduced in 1842 has been such that in 1890 the available supply was trebled and in 1917 it was doubled. Within the next ten years it will again have to be doubled, and yet, as compared with other cities, New York is very economical in its use of water.

For the year 1925 the city will use an average of over 800,000,000 gallons per day drawn from four sources, the Catskill Mountains, the Croton River, the Bronx River, and from the sands of Long Island in Nassau County. These sources are capable of furnishing a dependable supply of 1,050,000,000 gallons, divided as follows:

Catskill Mountains	600,000,000	gallons daily
Croton River	330,000,000	" "
Bronx River	20,000,000	" "
Nassau County	100,000,000	" "

As the city will consume at least an additional 25,000,000 gallons per day each year, it is apparent that, inside of ten years, more water must be available in order that the supply to the people need not be restricted.

Announcing~

Important New Designs

K KNOTT

OUR ENGINEERS are constantly on the alert to develop new apparatus which will contribute toward more efficient laboratory operation.
During the past year many important new designs have been added to our line. Every progressive engineer will be interested in them.
It is difficult to make a few selections which will give an adequate idea of the wide field which these improvements affect, but we shall present in the following issues of THE NEWS a few examples of the many which are available to you.

L. E. KNOTT APPARATUS COMPANY
CAMBRIDGE, MASSACHUSETTS

SINCE 1895

The Standard for Rubber Insulation

OKONITE
TRADE MARK

RUBBER COVERED AND VARNISHED CAMBRIC
WIRES and CABLES
are made with especial regard for Quality

All OKONITE products are carefully inspected and tested at each step in the manufacturing process so as to insure a perfect finished result.

Full details in Handbook—Send for it.

The Okonite Company
The Okonite-Callender Cable Co., Inc.
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Novelty Electric Co., Philadelphia Pa.
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Canadian Representatives: Engineering Materials Ltd., Montreal
Cuban Representatives: Victor G. Mendoza Co. Havana

INDUSTRIAL LIGHTING CODES.

In order to protect workers from accidents and eye sight damage, no less than five states, New York, New Jersey, Pennsylvania, Wisconsin and Oregon have now in force lighting codes for industrial establishments. Other states are now considering the adoption of an industrial lighting code, and it seems only a question of time when all the states will adopt such a code.

Proper lighting of work places is not only of great importance to the operators working therein, directly affecting their safety and eyesight, but it is a factor of equal importance to the employer, as quality and quantity of output are deciding factors of profit or loss in the operation of the plant.

The introduction to the Wisconsin code reads as follows: "Insufficient and improperly applied illumination is a prolific cause of industrial accidents. In the past few years numerous investigators, studying the cause of accidents, have found that the accident rate in plants with poor lighting is higher than similar plants which are well illuminated. Factories which have installed approved lighting have experienced reductions in their accidents which are very gratifying.

"Of even greater importance, poor lighting impairs vision. Because diminution of eyesight from this cause is gradual, it may take the individual years to become aware of it.

"This makes it all the more important to guard against the insidious effects of dim illumination, of glaring light sources shining in the eyes, of flickering light, of sharp shadows, of glare reflected from polished parts of work. To conserve the eyesight of the working class is a distinct economic gain to the state, but regardless of that, humanitarian considerations demand it.

"Finally, inadequate illumination decreases the production of the industries of the state, and to that extent, the wealth of its people. Factory managers who have installed improved illumination, are unanimous in the conviction that better lighting increases production and decreases spoilage."

The Wisconsin Commission has adopted a rule to the effect that, "diffusive or refractive window glass shall be used for the purpose of improving day light conditions or for the avoidance of eye strain, wherever the location of the work is such that the worker must face large window areas, through which excessively bright light may at times enter the building."

A glass is now available which meets the above requirements. It properly diffuses the light and prevents sun glare passing into the building and is known as Factrolite.

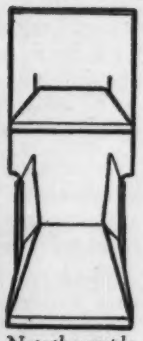
Engineers of to-day are making a thorough study of illumination, so that they may be able to plan and lay out industrial plants, to scientifically increase their efficiency to as near the maximum as possible. This accomplished the engineer is not only doing something worth while for his employer, but is doing quite as much for himself by coming into prominence with modern ideas.

If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

MISSISSIPPI WIRE GLASS CO.,
220 Fifth Avenue,
St. Louis. New York. Chicago.

Coarse Tooth Construction makes Modern Milling Cuts Possible

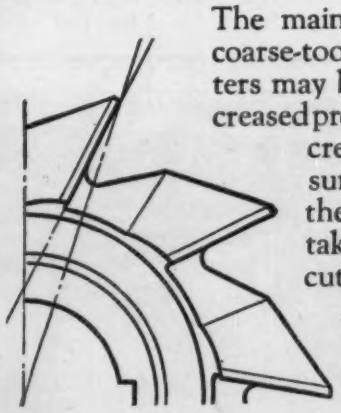
MODERN milling machines deliver exceptionally high power at the spindle and in order that this power be utilized efficiently for the removal of metal, the modern Brown & Sharpe Coarse Tooth Cutters were developed.



Note the ample chip space between the teeth

The free cutting action of coarse-tooth cutters is largely due to the fact that less cutting is actually required to remove a given amount of metal, each tooth taking a large, deep chip. This results in a considerable decrease in the tendency to slide over the surface and spring the cutter arbor.

The wide spaces between the teeth allow the cutting edges to be well backed up, adding to their strength, which was not always possible with closely spaced teeth. Therefore the cutters are well prepared to handle deep and rapid cuts without danger of failing.



The main advantages of coarse-tooth milling cutters may be stated as increased production and decreased power consumption, due to the heavier cuts taken and the freer cutting action.

At left—The drawing shows the increased angle of undercut and the well backed up teeth

BROWN & SHARPE MFG. CO.
PROVIDENCE, R. I., U. S. A.

Catalysis—the Modern Philosopher's Stone

(*Continued from page 192*)

yields can be obtained. The price of phthalic anhydride has dropped from $4.23 per pound in 1917 to 18 cents in May, 1925; recently a considerable amount was exported. About three-fourths of all the anthraquinone produced in the United States in 1924 was made synthetically from phthalic anhydride and benzene.

American chemists were pioneers in the development of the synthetic phenol resin industry. Many automobile parts are made from these materials, and large quantities of the resins are employed for manufacturing insulating devices, varnishes and lacquers, substitutes for amber in pipe stems, cigarette holders, jewelry, etc., and radio parts. Although there have not recently been many new catalytic developments in the preparation of these resins, those who make them have been experimenting on the production of methyl alcohol by the hydrolysis of methyl chloride secured from methane through chlorination. Recently it was discovered that dichloro-methane can be used to replace formaldehyde in the manufacture of plastics. Furfural, which can be obtained from corncobs, is a constituent of certain new, dark-colored resins.

The pyroxylin plastic, nitrocellulose, and varnish and lacquer industries require the production of large amounts of organic solvents. Among these are ethyl acetate, butanol, butyl acetate, and amyl acetate. Recently n-butyl alcohol has been made by the action of certain micro-organisms on carbohydrates; it is said that experiments are under way for the use of catalysts in producing this alcohol from natural gas, but no definite results are available.

Vulcanization of Rubber

Vulcanization, or treatment with sulphur, is a vital factor in the manufacture of most rubber goods. It is the usual practice to facilitate this process by the addition of substances known as accelerators. Inorganic compounds in this group include litharge, magnesia, and zinc oxide; among the more important organic accelerators are diphenyl guanidine, anhydroformaldehyde aniline, certain dithio-carbamates, and ethylidene aniline. Accelerators improve the mechanical strength of the rubber, shorten the time required for the "cure," and in some cases improve its resistance to atmospheric oxidation during subsequent use. Recently several articles dealing with the mechanism of accelerator action have appeared. Some investigators place emphasis on the intermediate formation of a polysulfide which splits off very active sulphur, and others stress the importance of organic zinc salts which are supposed to be sulphur carriers. Although views as to the accuracy of these theories may differ, it seems likely that the experimental work done in connection with them will aid rubber chemists in obtaining new and better accelerators.

Synthesis and Oxidation of Ammonia

Several plants for the production of ammonia by the union of hydrogen and nitrogen under high pressures were recently erected in the United States. The choice of a suitable catalyst for this process is vital to its success. Very pure iron mixed with small amounts of potassium and aluminum oxides, which act as promoters, appears to be the best catalyst. It is said that these compound catalysts are very efficient, and constitute a distinct improvement over those previously employed.

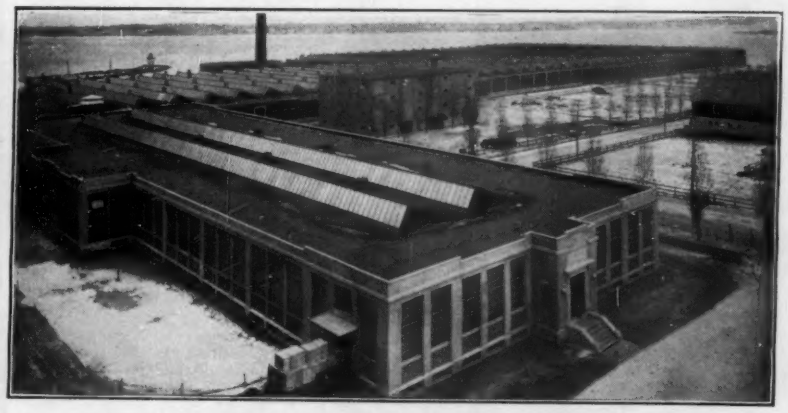
Until a short time ago platinum was regarded as the catalyst *par excellence* for the oxidation of ammonia in the production of nitric acid. On account of the high cost of this metal numerous attempts have been made to find a substitute for it. One investigator states that a mixture of cobalt oxide and a small amount of bismuth oxide will give results as good as those obtained with platinum.

Negative Catalysis and Stabilizers

One of the problems studied intensively during the World War was the prevention of the spontaneous polymerization and oxidation of acrolein, which was considered for use in chemical warfare. It was found that phenolic compounds, such as phenol, resorcinol, gallic acid, etc., exerted a retarding influence on these undesirable changes. Lately numerous attempts have been made to learn what substances would prevent or slow down the oxidation of rubber by atmospheric oxygen, the "souring" of cracked gasoline, the polymerization of hydrocyanic acid, etc. It has long been known that alcohol acts as a preservative for chloroform. Recent work has shown that inert substances like liquid petrolatum will retard the oxidation of chloroform. Although the field of negative catalysis is very important, comparatively little has been done along these lines, and there is need for much research.

Present Tendencies

Probably future progress in catalysis will depend largely on a better understanding of the mechanism of catalysis. It is gratifying to learn that at present there are a number of investigators working on this topic. Apparently many chemists are systematically studying catalysis and attempting to classify and to improve our knowledge. Undoubtedly these efforts will be fruitful in many ways.



One of the finest textile mills in the world, built by Wm. T. Reed Co. Several repeat orders have been received from this firm

WILLIAM T. REED CO.

Building Construction

200 DEVONSHIRE STREET, BOSTON

We are organized and equipped for the efficient handling of mercantile and industrial building construction of all descriptions.

To Prepare For Your Job

LOWER COSTS, greater safety and increased all 'round efficiency are resulting from the rapid advancement which is taking place in explosives engineering. At mines, quarries and on construction work throughout the world improvements in methods of drilling, blasting, loading, and transporting of coal, ore and stone are constantly being made, and every month some of these are reported in "The Explosives Engineer", a unique, illustrated periodical devoted to these important subjects.

NEW OFFER

Less than 3c a Month

WE are making a new offer of a three years' subscription to "The Explosives Engineer" for one dollar postpaid anywhere in the United States. This will apply to all of our present readers as well as to new subscribers. Each issue is exhausted shortly after publication, so it is advisable to send in subscriptions at once in order to secure the December number. Attach a dollar bill to the coupon and keep abreast of developments in mining, quarrying and construction for 36 months.

THE EXPLOSIVES ENGINEER
WILMINGTON DELAWARE

The December Issue

Students will be interested in the description of the construction methods in building the Exchequer Dam, on Merced River, in California. The site was selected at a narrow point of the Yosemite Valley, through which run the main tracks of the Yosemite Valley Railroad, daily carrying twenty-two trains. So that train service would not be interrupted, the dam was constructed with a temporary railway tunnel, until the road is changed. Insley towers and derricks are extensively used by the contractors. A portrait and biography of Arthur S. Bent, president of the constructing company, and past president of the General Contractors of America, are in the same number.

Since the close of the World War, the wave of general industrial activity in Austria has been the cause of a widespread use of explosives. In this issue, Rudolf Feuchtinger, of Vienna, describes drilling and blasting methods in his country.

"The Desert Prospector" will be depicted by reproduction of a series of pencil sketches drawn for *The Explosives Engineer* by W. D. White.

The importance of producing the maximum quantity of lump coal in the majority of the bituminous coal mines of this country has directed much attention to this phase of the industry. B. L. Lubelsky, explosives engineer of the Washington Gas Coal and Associated Companies, gives the blaster some important information in his article discussing the advantages of undercutting in the production of lump coal.

Regular features of every issue include the popular Blaster Bill and Wilyum Jan cartoons, and an index of the month's books, articles, and patents on drilling, blasting and allied subjects.

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I am enclosing $1.00 for a 3 years' subscription to The Explosives Engineer, to begin with the November issue if it is not already exhausted. (This rate applies only to the United States.)

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Please send me conditions covering the National Safety Competition for The Explosives Engineer Trophy. ☐

The Technical Graduate in the Public Utility Field

(*Continued from page 183*)

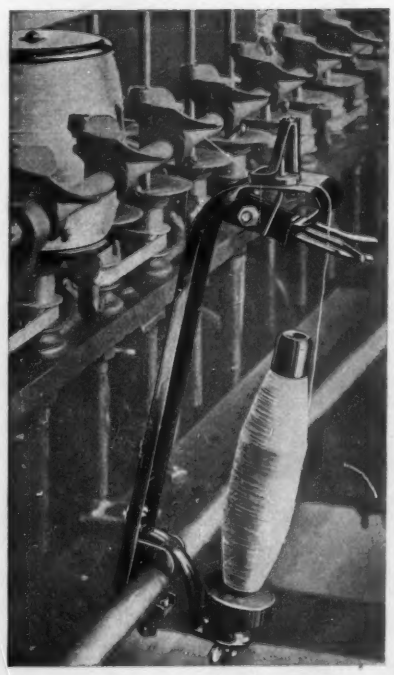
ments by proper construction and operation, by courteous and straightforward dealing with investors, customers, the public, state, and municipal authorities, regulatory bodies, and fellow employees. He must be able to aid in the development and extension of the market through rendering the best of service and the most economic utilization of resources. He must be able to help solve the company's problems, both technical and human, and to capably meet diverse situations as they develop.

An engineering education is considered to be practically an essential to the executive of the future, and is very desirable in every branch and sub-branch of a public utility, even in finance and accounting, strange as this latter may seem to many. Therefore, the men chosen for the training course are all graduates of engineering colleges. "They should be educated in all of the fundamentals of engineering and have the ability to use these fundamentals without conscious effort to meet methods, processes, conditions, and situations. It is considered unwise for the men to have specialized, as too early specialization tends to narrow one's vision and restrict his field of future usefulness. Specialization will most naturally come with experience. One graduate in a thousand may find opportunity in specialized design, but nearly everyone needs to know values and costs, and the laws of supply and demand. They should be men who finish what they start, who get what they go after, who are not easily discouraged by bad luck or criticism, and who will put forth every honest effort to succeed. They should be able to develop tact and diplomacy to meet the public fairly and openly and create friendly relations. They should be men of conservative judgment, but not bound by precedent, and who can be trusted to try out new and untried methods; men who think straight and through to conclusions; who, having will for action, act promptly, effectively, and justly; who quickly familiarize themselves with the vital factors of a situation and then form sound judgments, and who have ability to express those judgments in a manner to convince and stimulate others. They should realize that the operation of any utility is a business enterprise, and not merely the application of physical laws, and that safe and reliable and adequate service must be furnished and sold at a profit. They should be able to function properly in the organizations in which they work, with, through, and for others, and where emphasis is placed on accomplishment and service rather than on the acquirement or possession of knowledge. They should realize that initiative is most desirable, but it must be tempered with the spirit of co-operation and team-work."

The selected men are then given a course of training lasting two years, and embracing every phase of the public utility operations. The work is divided into four main divisions — Gas, Electrical, Accounting and Commercial, Securities and Budget. Every sub-department under these divisions is thoroughly covered, and the details of all of the work are gone into by the student. He spends two weeks in each of these sub-departments, and gets a basic knowledge of the operations. For instance, in the Accounting Department he spends two weeks each on Applications, Complaints, Collections, Meter Reading, Customers' Books, Control, Stores Department, Purchasing, Payroll, Taxes and Insurance,

(*Continued on page 214*)

YOUR PRODUCTION COSTS?



There is a way in which we may be able to lower YOUR production costs:

Stampings Are Cheaper Than Finished Castings

If there are any parts of your product now made of finished castings, we can probably stamp them out of sheet metal at a lower cost.

For nearly fifty years we have specialized in the production of metal specialties. This experience has been combined with modern machinery and skilled workmen.

PETER GRAY & SONS, Inc.

Manufacturers since 1878 of Sheet Metal Specialties

Third and Binney Streets - East Cambridge, Mass.

What Price Friction?

FRICTION is the proverbial wrench that gums the wheels of industry.

But Engineers today are making remarkable strides in the elimination of this drag on industrial progress. They are constantly finding new applications for anti-friction bearings—designing them into machinery with marked success to replace the old fashioned plain bearing.

You, as engineers, will soon enter various fields of industry, and perhaps will be called upon to solve friction problems.

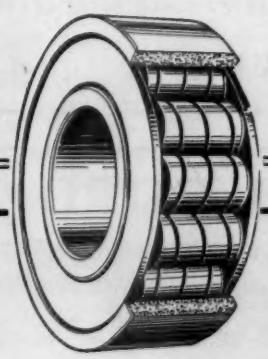
Do you know that for 35 years Hyatt roller bearings have been used as friction eliminators in many lines of industry? By their use, an easy, positive rolling motion is substituted for wasteful rubbing motion.

And Hyatt roller bearings are keeping in step with the times, constantly improved in construction to meet the demands for better and more durable anti-friction bearings.

HYATT ROLLER BEARING COMPANY

NEWARK DETROIT CHICAGO SAN FRANCISCO
WORCESTER PHILADELPHIA CHARLOTTE
PITTSBURGH CLEVELAND

So that you may study at close range the salient points of Hyatt Roller Bearings, we shall be glad to send you a sample bearing upon request.



HYATT
ROLLER BEARINGS

The Technical Graduate in the Public Utility Field

(*Continued from page 212*)

Vouchers, Securities Accounting, and Reports and Analysis.

The student works on a schedule assigned him at the beginning of the course, and the schedules are so arranged that only one student will be in any one department at any one time, thus allowing the student to receive the undivided attention of the men in that department. The student is not expected to produce anything, but is expected to assimilate the essentials of the operation of each department. He finds willing co-operation from the men, who are always glad to answer any questions which he may ask, no matter how simple they may seem, and to aid him in every way possible in his efforts to learn the business. The short space of time spent in each department necessitates that the student vigorously apply himself and put forth his best efforts, but it is long enough for him to become thoroughly grounded in the principles and methods of that department, if he does apply himself.

Upon the completion of each department, the student writes a report upon that work, which is graded by the head of that department and kept on file by the company. The head of the department also turns in a report upon the man, covering his personality, ability to make friends, ability to assimilate knowledge, willingness to work, etc., and this is also kept on file. Thus, the student writes his own record, as his work is judged by his two sets of reports, and it is entirely up to him whether or not he succeeds.

The students have a club of their own, which meets twice each month, and which gives dances at various intervals. At the meetings of the club, some of the company officials are usually invited to speak, and give the students a great deal of knowledge which is ordinarily unobtainable through the usual channels, but which they are enabled to impart due to their breadth of experience and knowledge. The club furnishes real social contact with all of the students and the officials, and there is that touch and spirit present that is found elsewhere only in a fraternity.

With the rapid expansion of the utility business, there are opportunities constantly opening up for the men from the school, and they are filled by the men who, in the opinion of their superiors and according to their own desires, are best fitted for that particular phase of the work. Not only do these opportunities occur in the strictly engineering field, but also in everything from sales to finance. From the company experience, it is easily seen that men with engineering training, broadened out by proper contacts and experience, can do anything in the public utility line. For instance, John McMillin, now a member of the executive committee of the Cities Service Company, specializing in finance, graduated in Mining Engineering from M. I. T. in 1907, and after training in the school, rose to his present high position in a field not generally accorded to be in the engineer's province. And that is only one of many similar cases.

That the company attaches great importance to the school is easily seen from the fact that they are willing to expend over $2000 per year per man, and that a vice-president of the company is placed in charge of the school. That the results of this expenditure have been successful is shown by the fact that over 66 per cent of the enrolled students are still in the employ of the company, and that over 80 per cent of the first five classes (1906 to 1910) who are still with the company are now managers of properties or hold positions of equal importance.

BUFF Instruments

save time—error—calculation

Engineers and contractors know that BUFF performance is accurate and sure—on all sorts of work, from running location lines to giving "neat lines" on important bridgework—without having to adjust the transit once.

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Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds, and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.
CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST
SAMSON CORDAGE WORKS -:- **88 Broad Street, Boston 9, Mass.**

Going Up

R. W. Owens

EVERY time you go up in a modern building having high-speed elevators (the Chicago Athletic Club, for instance) you are lifted by the ingenuity of at least one Westinghouse engineer who is barely ten years off the campus.

Until three years ago, high-speed elevators invariably required direct electric current. There was no practical method of using alternating current, and since many districts are supplied only with alternating current, a serious handicap existed.

It was possible to employ a motor generator to convert alternating current into direct current, but when that was done no practical system of control was available if the elevators were to be operated at high speed. The suggestion was made that the control be accomplished by varying the voltage of the generator and (among others) to a young man of thirty-three—R. W Owens, Illinois '14, now head of the direct-current section of the motor engineering department—came the special problem of designing an electric generator that would perform as one had never performed before.

The question is sometimes asked: Where do young men get when they enter a large industrial organization? Have they opportunity to exercise creative talents? Or are they forced into narrow grooves?

This series of advertisements throws light on these questions. Each advertisement takes up the record of a college man who came with the Westinghouse Company within the last ten years, immediately after graduation from his university.

Many were associated in the undertaking, for it involved pioneering in control apparatus as well as in generator design, but eventually all difficulties were overcome, and there emerged the "Variable Voltage Control System for Electric Elevators", now standard throughout the building industry.

Here you have the type of problem that confronts the design engineer in an organization like Westinghouse. Not all are as large as this, or lead to such sweeping results. The design engineer works for the customer. He starts with an analysis of the customer's needs and develops apparatus to meet those needs.

His responsibilities are varied and heavy. The jobs of the direct-current section of the motor engineering department range from motors for driving ventilating fans to those for dumping whole cars of ore at the docks. A force of 1,000 men is constantly occupied building the motors designed by this section.

Westinghouse

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers courses, each of four years' duration, in Civil, Mechanical, and Electrical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy, and Geology; Architecture and Architectural Engineering; Chemistry, Chemical Engineering, and Electrochemical Engineering; Biology and Public Health, and Sanitary and Municipal Engineering; Physics, General Science, and General Engineering; and in Engineering Administration. These courses lead to the Degree of Bachelor of Science.

To be admitted to the first-year class, applicants must have attained the age of seventeen years, and must satisfactorily fulfil entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History, and French or German, and one elective subject. Examinations are required in all subjects except Chemistry, History, and the elective, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June, applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago, and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted, without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, and Doctor of Science are also offered. Special Research Laboratories of Physical Chemistry, Applied Chemistry, and Science have been established.

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Bulletins of General Information, Courses of Study, Summer Session, Advanced Study and Research; and the Report of the President and the Treasurer.

Any of the above-named publications will be mailed free on application.

For information, address

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASS.

He Preferred The Ride

BERNARD was every inch a Swiss, from his knowledge of cuckoo clocks to his skill as a yodeler. So on his first visit to New York, his cousins watched with some amusement his amazed delight as the Otis Elevator whisked them to the top of one of the highest buildings. They looked forward to witnessing his thrill as he stepped out on the balcony which overlooked the vast panorama of lower New York.

To their disappointment he seemed to lose interest as soon as they left the elevator.

"Look down", they said to him, "You've never seen anything like this in Switzerland!"

Bernard shrugged his shoulders.

"This is all very well, but my own mountains are much higher. If you don't mind, I'll spend my afternoon going up and down in those elevators. It is not the height of these buildings which I find impressive; it is the fact that we don't have to climb to the top of them!"

THE METROPOLITAN BUILDING, New York, is one of the earlier tall buildings, but its dignity and pleasing lines make it a favorite, and it is hard to realize that the top of the tower is some six hundred feet above the sidewalk. In the tower portion of the building there are six (6) Otis Gearless Traction Machines, running at 600 Feet per Minute. In the main part of the building, the old high pressure hydraulic elevators are being replaced by twenty-nine (29) Otis Gearless Traction Micro Drive Elevators of the latest type.

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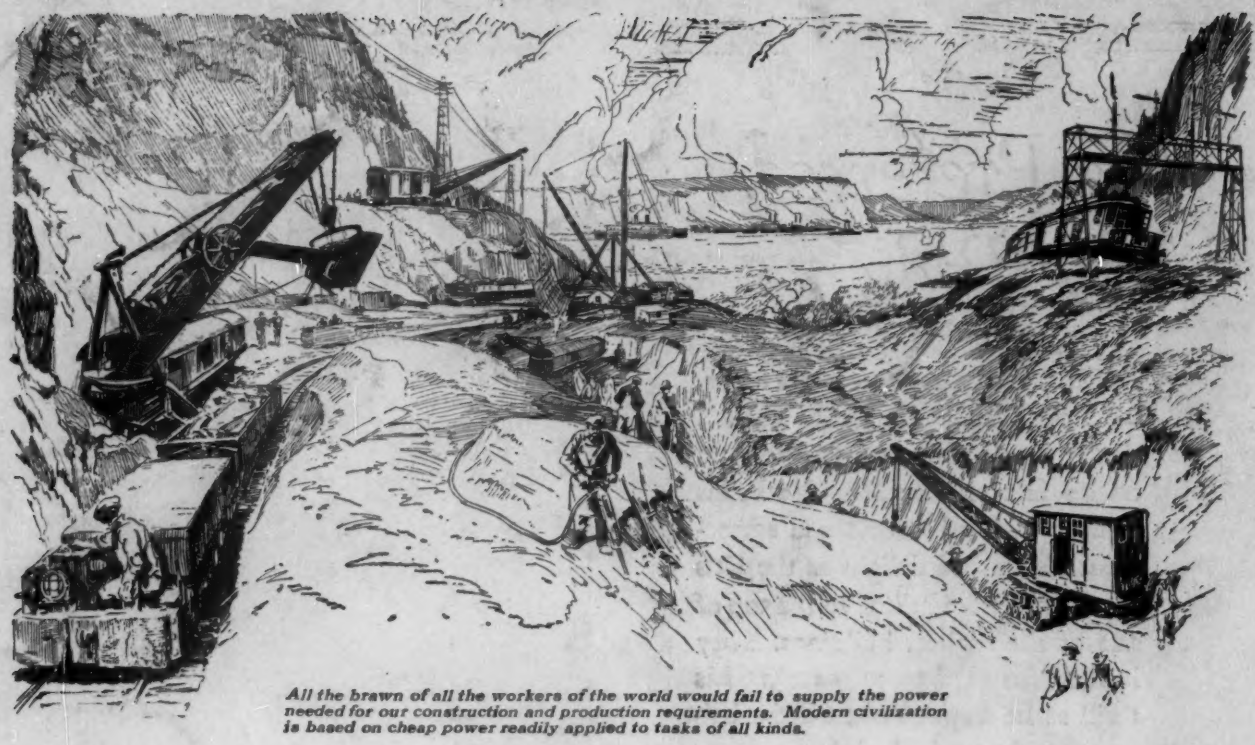

All the brawn of all the workers of the world would fail to supply the power needed for our construction and production requirements. Modern civilization is based on cheap power readily applied to tasks of all kinds.

Machinery *works*: Man *thinks*

According to college tests, man develops one-eighth horsepower for short periods and one-twentieth in steady work. As a craftsman—a worker who uses brains—he is well worth his daily wage. But as a common laborer, matching brawn against motorized power, he is an expensive luxury.

With a fifty-horsepower motor, for instance, one man can do the work of 400 common laborers. He is paid far more for his *brains* than his *brawn*.

The great need of this and future generations is for men who can plan and direct. There is ample motorized machinery for all requirements of production and construction. But motorized machinery, no matter how ingenious, can never plan for itself.

And that is precisely where the college man comes in. Highly trained brains are needed more and more to think, plan, and direct tasks for the never-ending application of brawn-saving electricity.

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